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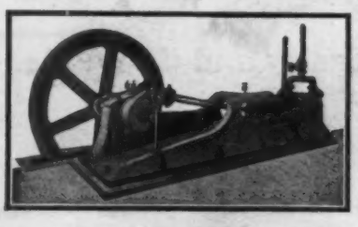

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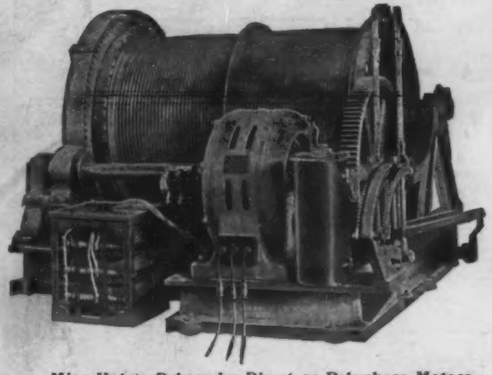

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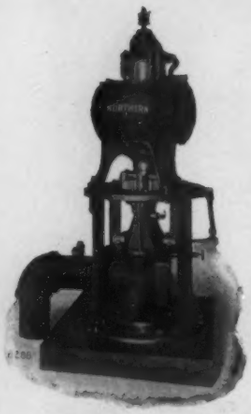
INDEX TO CONTENTS PAGE V. CLASSIFIED LIST OF ADVERTISERS PAGE XXV. ADVERTISERS INDEX PAGE IX.

301



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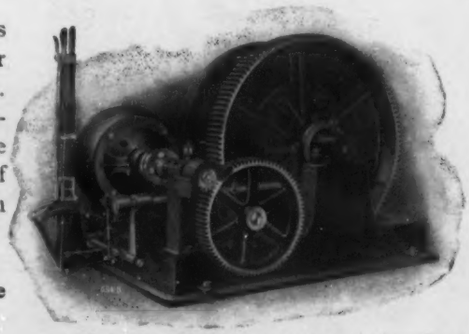

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The Journal of Electricity, Power and Gas.

Devoted to the Conversion, Transmission and Distribution of Energy.

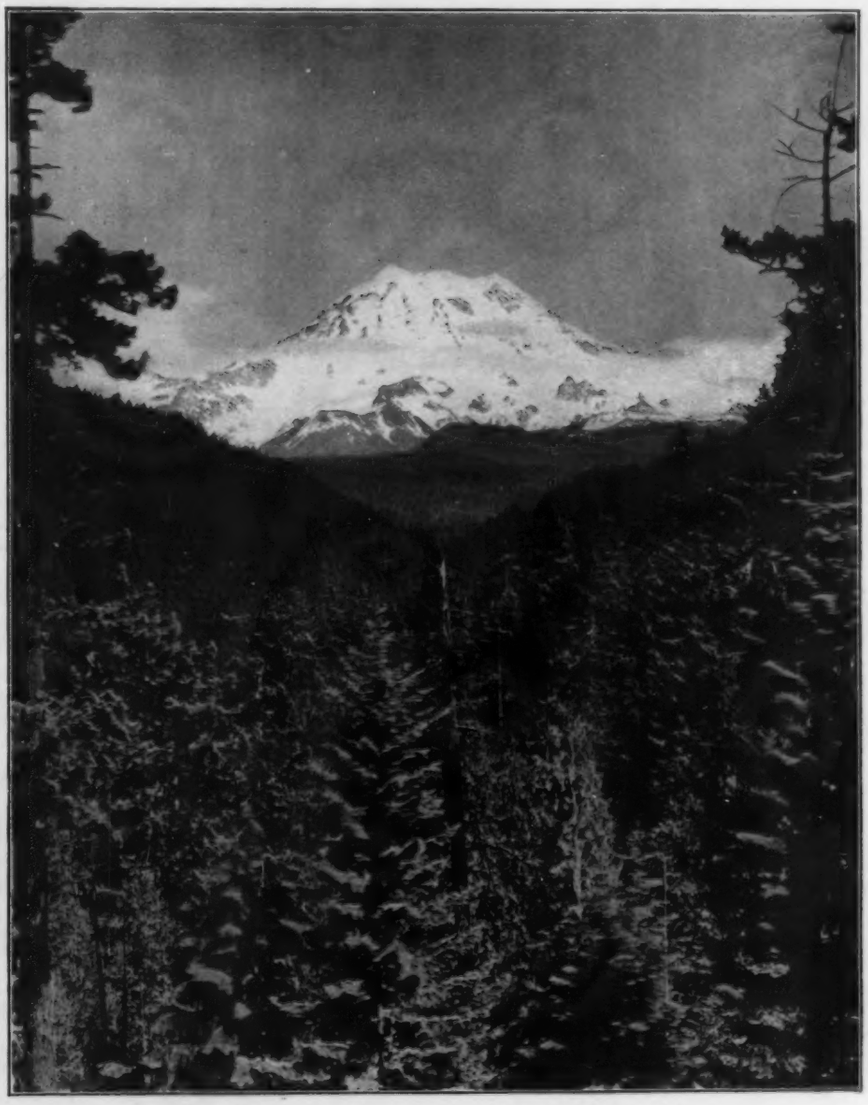
VOLUME XIV. SAN FRANCISCO, CAL., OCTOBER, 1904. NUMBER 10

The Puyallup River Water Power Development.

THE cities of Seattle and Tacoma, Washington, and their suburban towns, have in five years increased in population from 130,000 to upwards of 225,000; the growth of manufacturing industries and construction of street and interurban electric railways has kept pace with the increase of population, and to supply the consequent demand for electric power an unusually large generating plant of the most modern type has been constructed on the Puyallup River.

The Puget Sound Power Company, the owner of the plant, was organized in the year 1902 for the purpose of developing water power for use by the Stone & Webster properties in Seattle and Tacoma. Before beginning the construction of the plant a careful investigation was made of the variations in the flow of the several rivers in western Washington and the other features which would affect the reliability of the service obtainable from each, and a general plan was then adopted for the development of this power on the Puyallup River with an initial installation of 20,000 horsepower, the plans being made and the greater portion of the work carried out on the basis of continuing the initial installation to an ultimate development of 40,000 horsepower.

The design consists of diverting the Puyallup River just below the junction with the Mowich and carrying the same by means of a flume ten miles to a reservoir located on a high plateau, and thence discharging by means of steel pipes against wheels in the power house under a head of 872 feet, the water wheels so driven to be direct connected to electric generators, and the electric power so produced to be transmitted at a pressure of 55,000 volts forty-eight miles to Seattle and thirty-two miles to Tacoma. All water rights and the necessary land abutting on the river from the point of diversion to point of return were secured; also all land necessary for flume and other structures, and actual work of development was commenced March 1, 1903. To facilitate construction a spur track two and one-half miles long was built from the Kapowsin station of the Tacoma Eastern Railroad to a new station at Electron, and continued a mile further to the power house site. From Electron a standard gage cable incline was built to lift to an elevation of about 950 feet to the reservoir site above the power house, and a wagon road to the head works. The first generator unit



MOUNT RAINER FROM THE FLUME LINE NEAR AUTOMATIC SPILLWAY

MOWICH FALLS ON THE HEAD WATERS OF THE PUYALLUP RIVER

of 5000 horsepower was put into commercial operation delivering power to Seattle and Tacoma on April 14, 1904, less than fourteen months after work was commenced; the plant was put into complete operation for its initial installation of 20,000 horsepower on July 23, 1903.

The Puyallup River has its source in the glaciers of Mt. Rainier, next to the highest mountain in the United States and one of the great peaks of the world, covering 200 square miles and rising 14,500 feet above the waters of Puget Sound. That part of the mountain higher than 5000 feet above sea level is covered with snow and ice, and the precipitation resulting from the moisture laden air of the Puget Sound region coming in contact with the glacial cold of the mountain sides is estimated to average 140 inches per annum. The fields of ice and snow which result from this precipitation are constantly moving down the mountain sides to the valleys about its base in the form of slowly moving glaciers of many square miles in extent, which fill the valleys to the depth of hundreds of feet, and are constantly being added to from above and melting away below.

These great masses of ice increase in size and depth each winter and decrease by melting under the heat of summer, and the hottest and driest days of summer produce the greatest rate of melting. The Puyallup and Mowich rivers drain a fan-shaped section of the mountain and five of the glaciers described, and thence flow through mountain ranges which add greatly to their volume, each for a distance of about twelve miles from the glaciers, and then join together, the combined river being then known as the Puyallup. The watershed of these rivers includes a rough and heavily timbered country not covered with ice or snow and below the very high mountain range. The streams of this lower timbered country are fed by the copious rains of the Puget Sound country which occur during the fall, winter and spring months concurrently with cool weather. During such cool weather the rain and the run-off in this timbered section is heavy and at the same time snow and ice accumulate on the mountain and the run-off from it is comparatively small. When the warm weather comes the rain and the run-off from the timbered section is at a minimum and the melting of the snow and ice on the mountain and the run-off from the same is at a maximum. This balance, or alternation of the heavy run-off from the timbered and ice sections, results in a remarkably uniform flow in the river at the point from which the water is taken for power purposes, and makes the operating conditions in using this stream ideal.

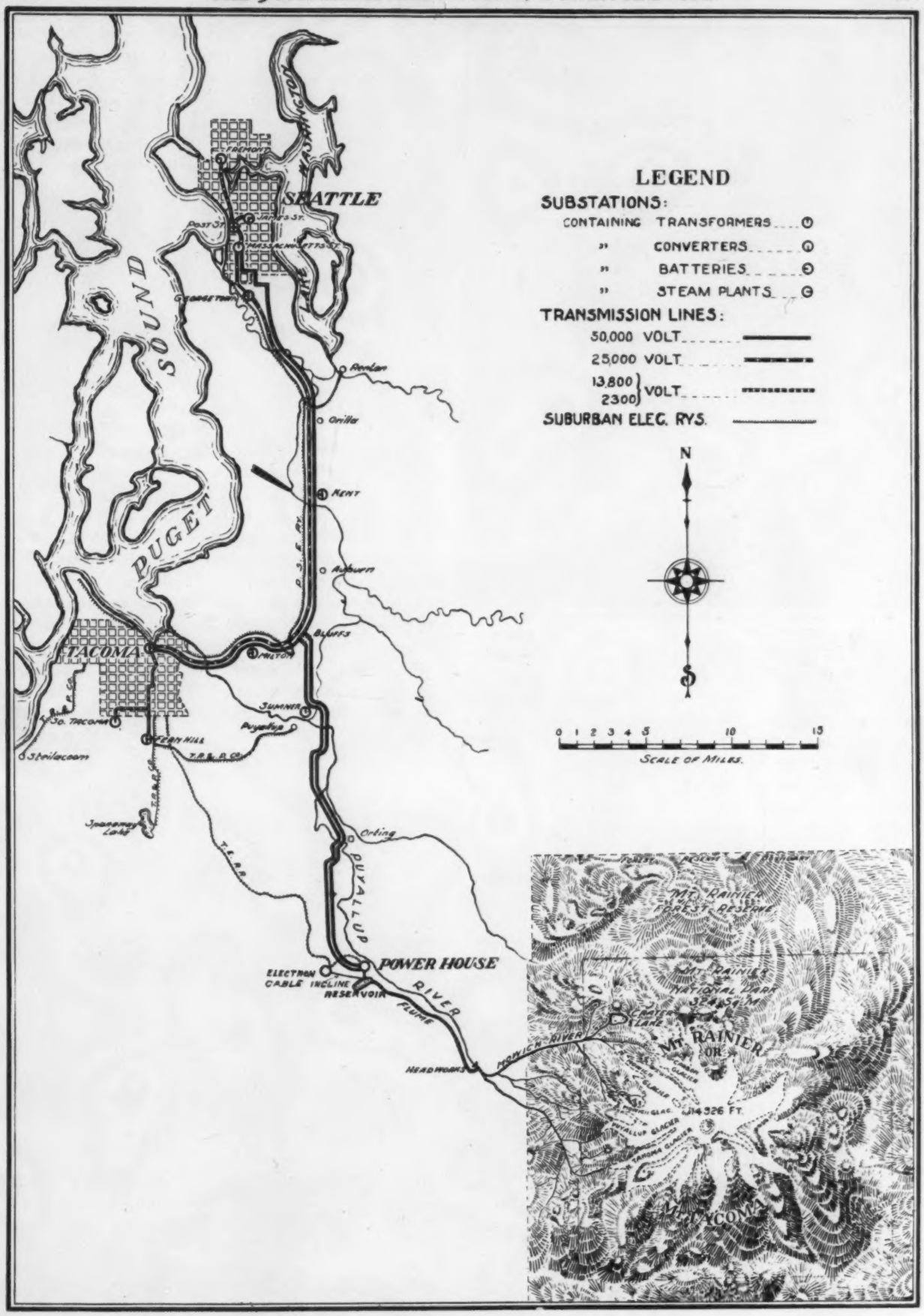
PARTIALLY CONSTRUCTED FLUME LINE SHOWING MOUNT RAINIER IN THE DISTANCE

VIEW OF THE TRANSMISSION LINES, CABLE INCLINE, RESERVOIR, PENSTOCK AND MOUNT RAINIER, LOOKING EAST

Although the dam and intake are located within ten miles of the nearest glacier, the elevation at this point of diversion is only about 1700 feet above sea level, and the climate at this elevation is so uniformly mild and the water flows so rapidly that no ice comes down the river nor is formed either in the flume or reservoir.

The power is used for all branches of service—light, power and railway. It supplies the electric railway systems in Seattle and Tacoma aggregating 168 miles of trolley road, the multiple unit, third rail line between Seattle and Tacoma, two cable roads, one in Seattle and one in Tacoma, furnishes power for numerous factories, together with the shops of the Northern Pacific Railway and the new pumping plant of the city of Tacoma, and supplies the greater portion of commercial and residence lighting and street lighting in Seattle and in the towns between Seattle and Tacoma.

Much of the power is distributed as alternating current —two-phase for power and single-phase for lighting—but there is also connected 10,000 kilowatts of converting



MAP OF THE PUYALLUP RIVER DEVELOPMENT OF THE PUGET SOUND POWER COMPANY, SHOWING ALSO AUXILLIARY TRANSMISSION LINES AND SUBSTATIONS OF THE PUGET SOUND ELECTRIC RAILWAY, SEATTLE ELECTRIC CO. AND TACOMA RAILWAY AND POWER CO.

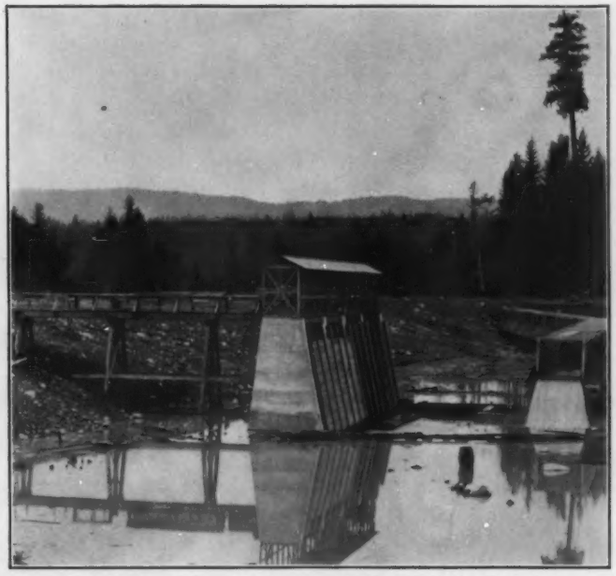
FLUME LINE THROUGH THE ROCK CANYON OF THE PUYALLUP RIVER

capacity for producing direct current, 2000 kilowatts of which is used for light and stationary motor supply. The bulk of the converting machinery (7300 kilowatts) being of the synchronous type, it is not necessary for the water power plant to generate or transmit idle currents.

The distribution of the current to the various localities and the transformation and conversion for various uses takes place at eleven substations containing 26,000 kilowatts of transformer capacity. Six of these are designed for transforming the 55,000-volt current to lower voltage and eight contain machinery converting to direct current for railway use. At a point one-half mile below the confluence of the Puyallup and Mowich rivers, and about 1700 feet above sea level, is located the dam and intake of the Puget Sound Power Company. Here the water necessary for the operation of its plant is diverted by a low, solidly constructed dam, through a masonry intake to a flume which is constructed on the southwest side of the river for a distance of ten miles. The dam or diverting weir is 200 feet long and five feet high, and covers the bed of the river longitudinally for a distance of sixty feet exclusive of the down stream apron. It is built down to an impervious bottom of clay hardpan, and is made tight by three rows of triple lap sheet piling set into hardpan bottom and bedded in concrete; it is faced with 6x12 timber covered at the crest with one-quarter-inch boiler plates, and besides the whole dam being a spillway, there is a lower spillway thirty feet wide to localize scour at the intake end. The intake is set at right angles to the dam and is constructed of concrete masonry. It is sixty-two feet wide at the river bank, and is protected by a screen grating made of iron bars one-quarter-inch by four inches by six feet, spaced two and one-half inches. Provision is also made for the insertion of flash boards in grooves in steel frames in such manner as to regulate or entirely shut off the intake at a point between the river and the grating. A radial gate of unique design is also installed at the junction of the masonry intake and the flume for the purpose of quickly controlling the amount of water delivered to the flume.

From head works to reservoir, a distance of about ten miles, the water is carried in a flume which as now constructed is eight feet wide and five feet high inside

INTAKE AND DAM, LOOKING EAST, SHOWING THE UNCOMPLETED RADIAL GATE AT THE LEFT



INTERIOR OF THE RESERVOIR DURING CONSTRUCTION, SHOWING THE ARRANGEMENT BY WHICH THE PLANT WAS OPERATED WITHOUT FILLING THE RESERVOIR

measurements, but is framed for the addition of plank to make it eight feet high. The flume is supported on low trestle work which follows the contour of the land. This trestle work is the same construction and of equal strength to that usually used for railroads, and in fact during the construction heavy work trains were operated over its entire length. The flume proper is constructed of surfaced planks two and one-quarter inches in thickness and twelve inches wide, and the frames which surround it are spaced with four feet centers, built on a uniform grade of seven and one-half feet to the mile. Sand boxes and automatic spillways are provided at various points along the flume, and a number of gates are also provided for emergency use, while a light railroad track for handcars of standard gage is laid along the top of the flume to facilitate inspection and repairs.

All danger timber along the line of the flume is being removed, and the flume trestle is built on rock or hardpan foundation which protects it against trouble from slides. In constructing this flume the usual plan of building curves as a series of tangents was not followed, the bends in the flume being made with true curves presenting a uniform and smooth interior surface and thus facilitating the flow of water.

The flume discharges its water into a reservoir located on a high plateau, nearly 900 feet above the power house. This reservoir serves as a relay to maintain the plant in continuous operation, in case of interruption of water supply, and also serves the very useful purpose of supplying water for temporary overloads in excess of the discharge capacity of the flume, or, in other words, for equalizing the daily fluctuations of load. The location of the reservoir is particularly well adapted for the purpose, the material excavated from the higher side of the site was used to form the embankment on the lower side of the reservoir. This material is a glacial boulder soil of clayey consistency which required blasting before it could be handled with a steam shovel. It puddled well and formed a water tight fill which set hard in the embankment almost like concrete.

The flume enters one end of the reservoir, and, when the latter is drained, as shown in the illustration, discharges into a concrete basin in front of the forebay. This arrangement permits the emptying of the reservoir for inspection or cleaning without interrupting the delivery of water to the power house, and distributes the water quietly to the penstocks without danger of carrying air into the pipes.

The forebay is of concrete and is constructed inside of the reservoir and is divided into compartments forming

AUTOMATIC REGULATING SPILLWAY AT THE ENTRANCE TO THE RESERVOIR, SHOWING THE BACK WATER OVERFLOW AND WATERWAY

separate gate chambers for the main penstocks. Each compartment is provided with iron racks or screens with stop boards to permit inspection or repairs without emptying the reservoir. The gates are arranged for connecting an electric motor drive to be controlled from

PANORAMIC VIEW OF THE RESERVOIR AND FOREBAY POOL, SHOWING THE SIMULTANEOUS OPERATION AND CONSTRUCTION

A PANORAMIC VIEW OF THE WATER INLET, FOREBAY AND PARTIALLY FILLED RESERVOIR

the power house. The depth of water in the reservoir is at all times shown at the power house switchboard by a Dibble automatic electrical indicating and recording water gage fitted with low water alarm. This gage is operated by three wires running from a float-actuated Dibble transmitter located in the reservoir.

The penstocks, one for the two exciters, one for each of the four generating units now installed and one for each of the remaining four units to be installed later, are carried through the reservoir embankment in the form of concrete protected wood stave pipes, joining the steel pipes just outside the reservoir embankment. Of the eight main pipes for the complete plant, four, together with the exciter pipe, are now continued about 1700 feet down an incline of about thirty degrees to the power house on the river bank below. Each main pipe is of riveted steel forty-eight inches in diameter and one-quarter-inch thick at the upper end, tapering to thirty-six inches in diameter and three-quarter-inch thick at the lower end, and was furnished by the Risdon Iron and Locomotive Works. The penstocks are anchored by massive concrete abutments, and all surface water is carefully drained away, and as a further security the pipes are protected with back filling of earth on which is planted quick growing vegetation.

The power house is built in the bank of the river on a foundation of piling and rock; it is of massive concrete, brick and steel construction; the building for eight units will be about one hundred by two hundred and sixty-six feet, divided longitudinally into two parts, a generator house and a transformer and switching house. The generating units are arranged parallel to and along the river side of the building, the penstocks being brought to them under the main floor from the rear. The transformers are grouped in isolated rooms of concrete in the basement of the switch house; the switching apparatus and wiring being in compartments overhead as hereafter described.

Each unit consists of two overhung Pelton water wheels, ten feet six inches in diameter, mounted on each end of the shaft of each 5000 horsepower two-bearing generator; the nozzles are of the needle type arranged for automatic deflection by Lombard type L governors for speed control, the operation of the needles being only for economic adjustment of the discharge to the load of the machine; each nozzle is also provided with a motor-operated gate valve for cutting off the water supply. The wheels have a maximum capacity of 7500 horsepower for each unit.

The wheels are arranged to be started and stopped and adjusted for speed from the main operating switchboard at one end of the generator room; motor-driven pumps provide oil supply for ordinary lubrication, pressure oil for forced lubrication in starting, and circulating water for cooling bearings.

The rotors and wheels are hydraulically forced onto a twenty-four-inch hollow nickel steel fluid compressed shaft. The spray from the wheel discharges collecting in the water wheel housing enters this hollow shaft and automatically serves to cool the bearings. At the date of their installation these were the largest impulse wheel units in the world.

INCLINE CABLE RAILWAY FOR HOISTING BUILDING MATERIAL UP THE 68 PER CENT. GRADE FROM ELECTRON TO THE RESERVOIR

There are four General Electric Company make revolving field generators of 3500 kilowatts capacity each, with an overload capacity of 25 per cent. for two hours, wound for three-phase current at 2300 volts and a frequency of sixty cycles per second.

Two 150-kilowatt, 125-volt, 600 revolutions per minute, shunt wound exciters are provided, each direct connected to an overhung Pelton water wheel and to a 2080-volt, 200 horsepower, three-phase induction motor. The wheels driving exciters are not provided with automatic governors, the direct connected induction motors serving this purpose, and operate either as motors or generators according as they run below or above synchronous speed. The motors also afford a relay source of power for excitation in case of failure of an exciter water wheel or its water supply. Each exciter is capable of exciting six generators under all conditions.

There are three banks of transformers installed at the power station, each bank consisting of three 2333-kilowatt, water cooled, oil insulated, General Electric Company transformers, with 25 per cent. overload capacity for two hours. Each bank has a capacity equivalent to two generators, the third bank being spare, so that the failure of even a complete bank would not diminish the capacity of the station. The transformers are connected delta on both the high and low tension sides, and the arrangement of the windings is such that with 2300 volts on the low tension side, high tension voltages of 27,500, 45,000 and 55,000 may be derived. These transformers have been operated at 55,000 volts from the beginning.

Water for cooling is derived from a spring above the power house, supplemented by connection with the reservoir. The transformers are piped so that the oil can be removed from the cases into large storage tanks, and an emergency blow-off valve is arranged to discharge the oil quickly into the river.

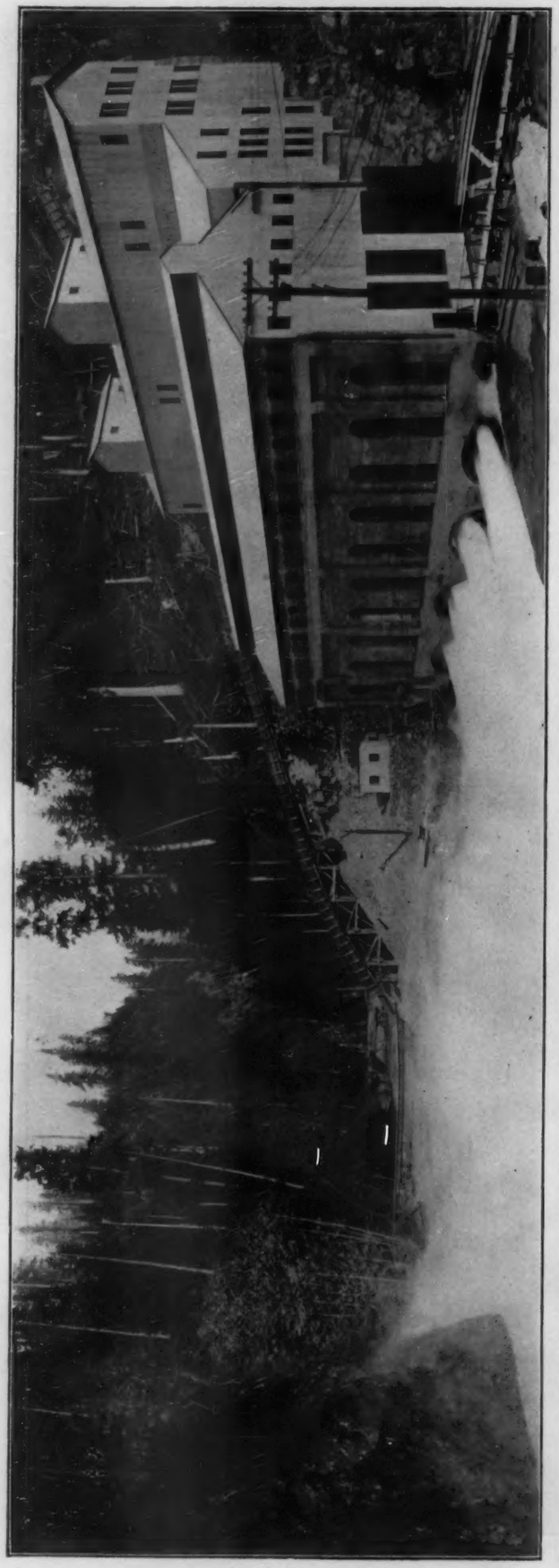
Before filling these transformers with oil they were dried out at a temperature of 80 degrees Centigrade under a vacuum of twenty-six inches for ten hours. No oil was used that did not stand a potential test of 40,000 volts between one-half-inch flat electrodes placed two-tenths of an inch apart. After filling and allowing the oil to thoroughly settle, samples of oil from the bottom and top of each transformer were subjected to the above potential test, and no transformer was put into service before the oil passed this test satisfactorily.

For connecting each generator and transformer bank to the low tension busbars, and each transformer bank and transmission line to the high tension busbars, a full complement of remote control, motor-operated oil switches is provided.

There are two sets of 2300-volt busbars, designated as the main and auxiliary busses. The main bus is for regular operation, while the auxiliary bus is for emergency operation and for relaying the main bus in case of repairs to the latter. Both sets of busbars are identical, and any transformer bank can be connected to either set.

Between each generator and each set of 2300-volt busbars there are two sets of disconnecting switches and a triple pole General Electric Company's type H, 1200-ampere, motor-operated oil switch, a set of disconnecting

CAMP 2, SHOWING THE SUPERINTENDENT'S COTTAGE, THE POWER HOUSE AND PENSTOCK LINES LOOKING SOUTH



WEST VIEW OF THE POWER HOUSE, SHOWING FOUR GENERATORS IN OPERATION; ALSO SHOWING THE TEMPORARY END WALL AND GRADING AND TRENCHING TO THE RIGHT TO FACILITATE THE INSTALLATION OF THE FOUR ADDITIONAL PENSTOCKS AND GENERATORS

switches being on either side of the oil switch. Between each set of burbars and each transformer bank there are two sets of disconnecting switches and a type H, 3000-ampere, motor-operated oil switch, the arrangement being similar to that of the generator switches. The purpose of the disconnecting switches is to remove the potential from the oil switches that inspection of or repair to the oil switches may be safely made. The disconnecting switches are not to be operated when carrying current except under emergency conditions. All ordinary switching is done by means of the oil switches, which simultaneously open and close the three legs of the three-phase circut. In addition to the single pole, double throw switches mounted on the operating panels for opening and closing these switches, when cutting in or out a generator or transformer bank, there is for each oil switch a clock-type time limit relay actuated by secondary current from current transformers in circuit with that switch, these relays operating the motor connected to the oil switch in case of an overload or short circuit lasting the period for which the relay is set. These relays can be set for overload periods of four seconds down to a small fraction of one second, it thus being possible to automatically localize short circuits on the system, and in apparatus, without completely shutting down the system. The electrical arrangement of the motors driving the exciters is the same as that of the generators.

There is one set of high tension busbars, divided into three sections by sectionalizing switches, each transformer bank being connected to a corresponding section, and one line to each of the end sections.

Between the high tension bus and each bank of transformers there are two sets of disconnecting switches and one triple pole, General Electric Company, 60,000-volt, 400-ampere, motor-operated oil switch, a set of disconnecting switches being on either side of the oil switch. There are two outgoing high tension lines, and each line is controlled, as just described, for the transformer banks. All the high tension oil switches possess automatic features as described for the low tension oil switches.

Lighting arresters without reactance coils are provided for each outgoing line.

Static dischargers are provided for the low tension side of each transformer bank. These static dischargers consist of three 2500-volt single pole lighting arresters connected in star, the neutral point grounded. They limit the potential of the low tension winding to 2500 volts above ground, and would come into action in case of grounding of one side of the transmission line or transformers.

The control of all the oil switches is from operating panels erected on a gallery in the east end of the generator room, at an elevation of fourteen feet above the generator room floor. The arrangement of panels from left to right is exciter panels (generator end), exciter panels (motor end), generator totaling panel

END VIEW OF THE POWER HOUSE SHOWING FOUR GENERATORS IN OPERATION. THIS VIEW SHOWS THE TEMPORARY END WALL AND THE TRENCHING AND GRADING IN PROGRESS AT THE RIGHT TO FACILITATE THE INSTALLATION OF THE FOUR ADDITIONAL UNITS.

generator panels, transformer control panels, and high tension line panels.

The generator and exciter field rheostats are hung below the gallery and are operated from pedestals by means of shafting and bevel gearing, the contact plates being on the rheostat boxes. The highest alternating current potential on the switchboard panels is 115 volts, derived from potential transformers, and the highest direct current potential is 125 volts, derived from the exciters. Each generator panel contains three ammeters, one voltmeter, a polyphase indicating wattmeter, a polyphase integrating wattmeter, and a field ammeter.

Each outgoing line panel contains three ammeters, and the totalling panel contains a power factor indicator, a frequency indicator, a curve-drawing voltmeter and three curve-drawing ammeters. The curve-drawing instruments belong to a type lately developed by the General Electric Company, giving a record three inches long per hour.

The control of the plant is completely from the switchboard gallery, a water wheel may be started or stopped, a generator brought up to voltage, synchronized with other generators on either bus, a transformer bank cut in on either bus and a transmission line connected in circuit without the presence of a person in the room where the actual switching is done, the lighting of a red lamp indicating the closing of a switch and a green lamp the opening of a switch.

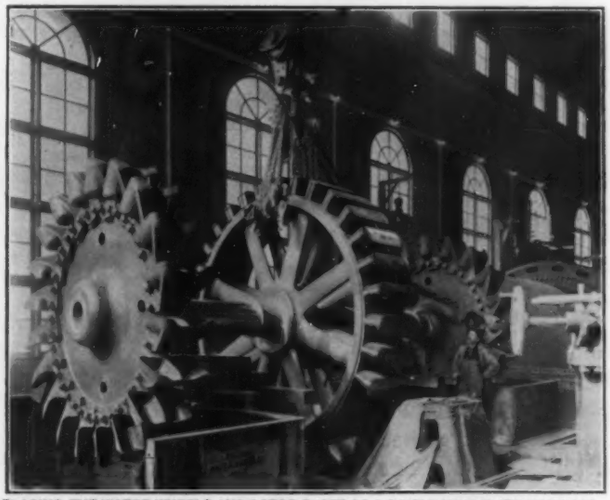
Figures *A* and *B* show sections through the generator room and switch house. The transformer rooms are at the same level as the generator room, but isolated from the latter by rolling steel doors. On floor No. 2 are the low tension disconnecting switches, the generator and transformer cables going to the sets of disconnecting switches on either side of the middle partition; the disconnecting switches installed between the oil switches and the bus being on the outer walls and immediately below the busbar compartments, which are above on floor No. 3. In the center of floor No. 3 are the low tension oil switches, the two oil switches corresponding to a generator or transformer bank being arranged back to back and facing their corresponding set of busbars. The busbars are of the laminated type, consisting of flat copper bars with expansion joints and supported on marble slabs set on edge which in turn rest on concrete slabs forming barriers between abjacent busbars. The compartments formed by the concrete slabs are to be covered by insulating fireproof doors.

The oil switches are installed in brick cells with soapstone bottom and top slabs and doors. Each pole of a switch is separated from the other poles by brick barriers.

The same general scheme is used for both the low and high tension disconnecting switches and oil switches, except that only one set of high tension busbars is at present installed, provision being made for the later installation of the second set. The high tension disconnecting switches and current transformers are on floor No. 5, while the high tension oil switches are on floor No. 6. Above floor No. 6 are the two outgoing high tension line towers, in the north end of which are the high tension lightning arresters, each pole being separated from its adjacent pole by brick barriers extending the full length of the arrester. The lines emerge from the wire tower centrally through an extra heavy thirty-inch sewer tile covered by a glass plate.

From the power house two parallel transmission lines run a distance of twenty-two miles to Bluffs, a station on the line of the Puget Sound Electric Railway, nine miles from Tacoma and twenty-five miles from Seattle. From Bluffs one line runs for a great part parallel to the transmission line of the Puget Sound Electric Railway to Seattle and one to Tacoma; also parallel to the transmission line of the Puget Sound Electric Railway.

The transmission line of the Puget Sound Electric Railway is at present operating at 27,000 volts, but the line is designed for operation at double this voltage, so that when this line is changed over to a 55,000-volt basis there will be two complete and independent pole lines from the power house to Seattle and Tacoma. At Bluffs there are erected junction pole switches by which the



PLACING THE WATER WHEELS AND ROTOR SHAFT OF A SINGLE UNIT IN ITS BEARINGS.

two transmission lines may be cut through independently, one to Seattle and one to Tacoma, or both lines put in multiple, or any section isolated without interfering with the operation of the other sections.

From the power house to Bluffs a private right of way has been secured, the two pole lines being from fifty to eighty feet apart. When passing through wooded sections all dangerous timber has been cleared well back on the land adjacent to the right of way on both sides, so as to completely protect the transmission line.

The minimum length of poles used was forty-five feet, with a minimum top diameter of ten and one-half inches. The standard spacing is 125 feet on straight line and 90 to 100 feet on curves.

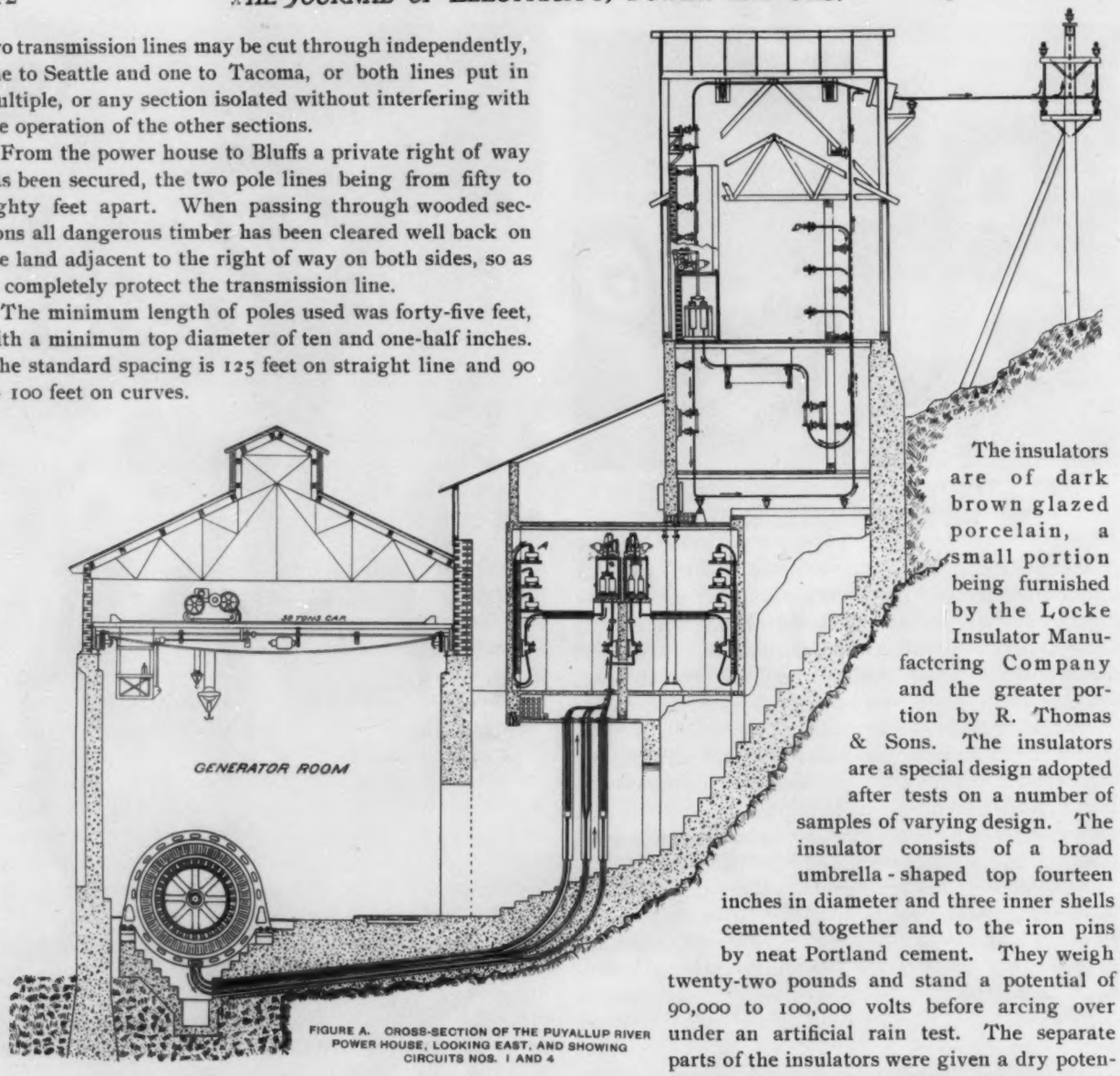


FIGURE A. CROSS-SECTION OF THE PUYALLUP RIVER POWER HOUSE, LOOKING EAST, AND SHOWING CIRCUITS NOS. 1 AND 4

The insulators are of dark brown glazed porcelain, a small portion being furnished by the Locke Insulator Manufactcring Company and the greater portion by R. Thomas & Sons. The insulators are a special design adopted after tests on a number of samples of varying design. The insulator consists of a broad umbrella-shaped top fourteen inches in diameter and three inner shells cemented together and to the iron pins by neat Portland cement. They weigh twenty-two pounds and stand a potential of 90,000 to 100,000 volts before arcing over under an artificial rain test. The separate parts of the insulators were given a dry potential test at the factory before shipment, and after assembly at Tacoma and before shipping out on the line they were again tested to a potential corresponding to the dry arcing-over voltage. So far the behavior of these insulators under the weather conditions that have existed since the plant was put into operation, and under a line voltage of 55,000 volts, has been entirely satisfactory.

The main cross-arm is five-inch by seven-inch by seven-foot four-inch Washington fir, boiled in raw linseed oil, giving it a much longer life than an untreated arm. This arm is bolted to the pole by two galvanized iron bolts and braced by a combination wood and galvanized iron brace. At the top of the pole is a five-inch by seven-inch by eighteen-inch arm supported by an angle iron frame bolted to the pole by two galvanized iron bolts. The main arm supports two insulators and the top arm one insulator, giving an equilateral triangular spacing of seventy-two inches between wires.

The pins on one line from the power house to Bluffs and from Bluffs to Seattle and Tacoma are galvanized malleable iron, cast hollow and circular in cross-section and having a shank diameter of two and one-half inches. The pins on the other line are of the same general exterior form and dimensions, but turned from eucalyptus wood and treated with linseed oil. The iron pins and eucalyptus pins are entirely interchangeable in all parts of the construction.

The line wire on both lines from the power house to Bluffs and from Bluffs to Seattle is nineteen strand 4/0 semi-hard drawn copper cable, and from Bluffs to Tacoma is solid 1/0 semi-hard drawn copper wire. The wires are transposed, making a third of a turn about every four miles. The telephone line is supported on cross-arms seven feet below the main arm, and consist of two No. 10 hard drawn copper wires, transposed every tenth pole, the glass insulators being double petticoat, deep groove, on locust pins. The operation of the telephone line with the above construction has been entirely satisfactory. The company also has an independent telephone line

leased from the Sunset Telephone and Telegraph Company and constructed over another route.

Eighteen miles from the power house and along the transmission line from the power house to Bluffs is the town of Sumner. In Sumner has been built a substation to accommodate two 100-kilowatt, 50,000 to 2300-volt transformers for local power and lighting. At present only one transformer has been installed, furnishing current for lighting Sumner. A 2300-volt line will be built from Sumner to Puyallup, a distance of three miles, for supplying the city of Puyallup with current for lighting and power, taking the place of the steam plant at present in operation.

The receiving station in Seattle is built on Massachusetts Street, near the southerly city limits. Here

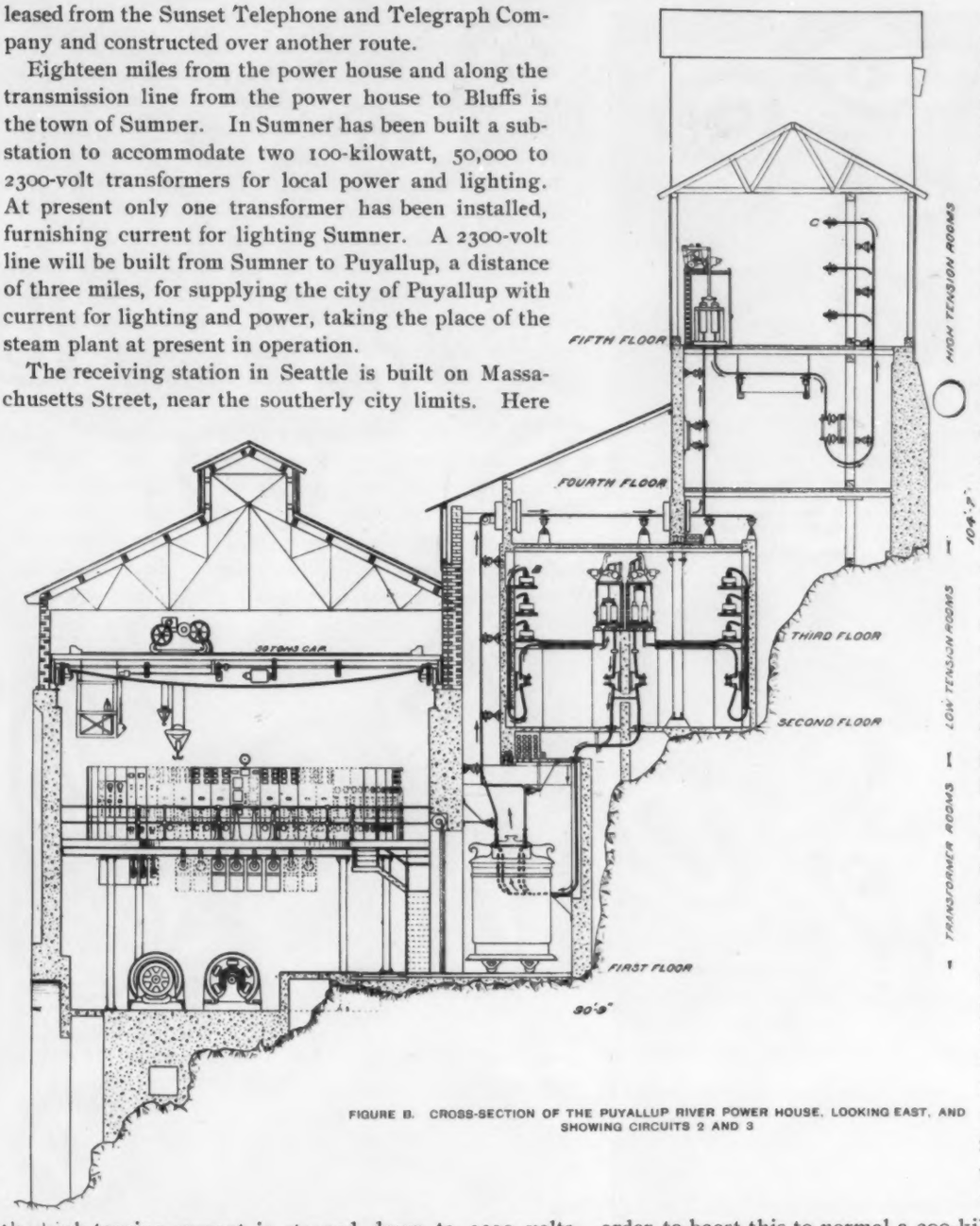
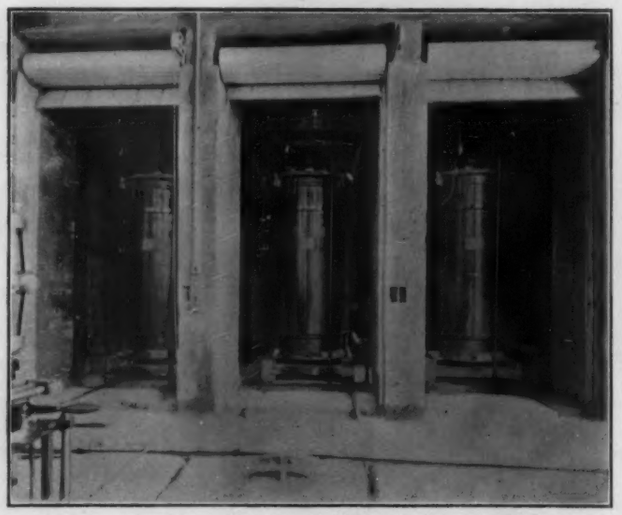


FIGURE B. CROSS-SECTION OF THE PUYALLUP RIVER POWER HOUSE, LOOKING EAST, AND SHOWING CIRCUITS 2 AND 3

the high tension current is stepped down to 2300 volts for local distribution to the stations of the Seattle Electric Company.

Control is provided for the two incoming high tension lines by means of high tension motor-operated oil switches, and for two 4000-kilowatt banks of transformers and for three outgoing 2300-volt feeders. The control of the transformers consists of a motor-operated, 60,000-volt, 400-ampere oil switch on the high tension side of each bank of transformers, and a motor-operated, 2500-volt, four pole oil switch on the low tension side of each bank. The control of the 2300-volt outgoing feeders is by motor-operated, four pole oil switches similar to the transformer low tension switches, differing only in capacity, the former being 800 amperes and the latter 1200 amperes capacity. All of the oil switches have time limit relays for automatically opening the switches in case of overload or short circuits. There are installed four 2000-kilowatt transformers in two banks of two each, transforming from 50,000 volts three-phase to 2300 volts quarter-phase. The arrangement of the windings is such that 50,000, 40,000 and 25,000 volts can be used on the high tension side, and low tension voltages of 13,800, 6900 and 2300 volts may be obtained. The two transformers constituting a bank are connected T, but using the full winding in the teazer transformer rather than 87 per cent., as in the usual Scott three-phase-two-phase connection. This produces only 1990 volts on the low tension side of the teazer transformer with 2300 volts on the main transformer, and in order to boost this to normal a 200-kilowatt transformer, called a compensator, having the full ampere capacity in the boosting coil of the 2000-kilowatt transformer and a ratio of transformation of 1990 / 310, is installed. This makes it possible to omit all 87 per cent. taps on the high tension winding, of which there would be a number, for the three primary voltages above stated, and simplifies the transformer construction. All the transformers, including the compensators, are water cooled, the water for cooling being primarily derived from the city service, but re-cooled by a cooling tower to effect economy by the re-use of water.

There is in addition to the above apparatus, two 500-kilowatt transformers in this station with a ratio of transformation of 25,000 to 2200 volts, installed for con-



VIEW FROM THE GENERATOR ROOM, SHOWING ONE OF THE THREE GROUPS OF STEP-UP TRANSFORMERS, EACH GROUP CONSISTING OF THREE 2300-KILOWATT 2300 55,000-VOLT TRANSFORMERS. EACH GROUP OF THREE TRANSFORMERS IS PLACED IN A CONCRETE CELL WITH CONCRETE AND BRICK VENT THROUGH ROOF, THE ENTRANCE TO THE CELLS BEING PROTECTED WITH IRON ROLLER DOORS

nection to the transmission line of the Puget Sound Electric Railway.

For measuring the input of power into the 2300-volt busses a graphic recording voltmeter, ammeter and wattmeter are provided in addition to the integrating wattmeter.

Lightning arresters identical with those at the power house are provided for each of the incoming lines. Marble barriers between adjacent poles of the arresters are installed to prevent the travelling of an arc from one leg to another.

Four-pole static dircharges are installed on the low tension side of each transformer bank, their purpose being the same as those at the power house.

For controlling the voltage of the 2300-volt outgoing feeders there is installed in each feeder a motor-operated induction regulator each of a capacity of 340 kilowatts.

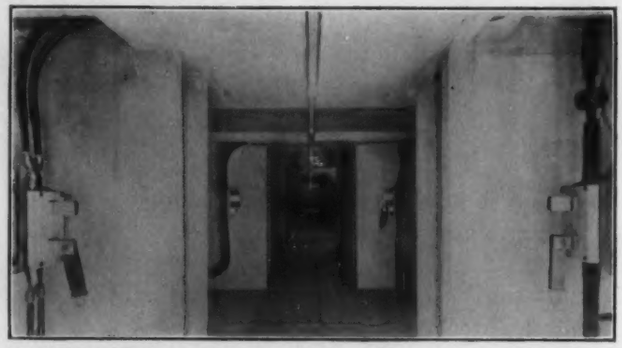
LONGITUDINAL VIEW OF THE NORTH SIDE OF THE THIRD FLOOR OF THE CONCRETE SWITCH HOUSE, SHOWING TO THE LEFT ONE SET OF 2300-VOLT BUSBARS AND WITH CONCRETE BARRIERS, AND TO THE RIGHT THE REMOTE CONTROL GENERATOR AND TRANSFORMER 2300-VOLT OIL SWITCHES. THIS ENTIRE ARRANGEMENT IS DUPLICATED ON THE SOUTH SIDE OF THIS FLOOR

These regulators boost or lower equally each leg of each phase.

The power is transmitted at 2200 volts, two-phase, from the Massachusetts Street substation to Post Street station, and from there also at 2200 volts, two-phase, to James Street station and Fremont substation.

Post Street station contains nine 500-kilowatt rotary converters, each with two 300-kilowatt transformers, five giving 500-volt current for railway and four 250-volt current for lighting; also six 50-kilowatt tub transformers for street lighting. This station is a steam relay station and contains two 2500-kilowatt overload capacity, 60-cycle, 2200-volt, two-phase alternators, each driven by a vertical compound McIntosh & Seymour engine; also a 1000-kilowatt lighting and a 500-kilowatt railway battery. The station contains the general switchboard for controlling the whole distribution in Seattle.

James Street station contains two 300-kilowatt induction motor-generator sets giving 500-volt railway current. It is also a steam relay station, with three 150-kilowatt railway generators driven by a double Corliss engine. When operated on a water power basis the railway gen-



LONGITUDINAL VIEW OF THE NORTH SIDE OF THE SECOND FLOOR OF THE CONCRETE SWITCH HOUSE, SHOWING THE 2300-VOLT DISCONNECTING SWITCHES PLACED BELOW OIL SWITCH ROOM. NOTE THE BARRIERS BETWEEN DISCONNECTING SWITCHES

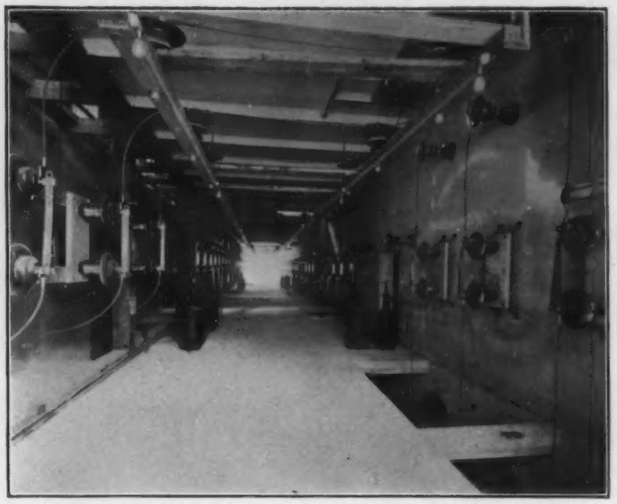
erators are used as motors to operate the James Street cable road.

Fremont substation contains two 300-kilowatt motor-generator sets, one induction and one synchronous, the motor end of each being 2200 volts, two-phase, and the generator end 500 volts direct current. There is also installed a 300-kilowatt railway battery.

The Seattle Electric Company has in addition to the above, two steam relay stations not used as substations. These are equipped with direct current machinery for railway and light and have a combined capacity of 1500 kilowatts.

The receiving station in Tacoma is a new brick building, built adjacent and as an addition to the steam station of the Tacoma Railway and Power Company. Control for two incoming high tension lines is provided as described for Massachusetts Street substation. One 4000-kilowatt, 50,000 to 2300 volts, transformer bank is installed with automatic oil switch control on high and low tension sides.

There are also installed two 500-kilowatt step-up transformers, transforming from 2300 volts, two-phase, to



LONGITUDINAL VIEW ON THE FOURTH FLOOR OF THE CONCRETE SWITCH HOUSE AND SHOWING THE CURRENT TRANSFORMERS FOR INSTRUMENTS AND THE HIGH TENSION DISCONNECTING SWITCHES FOR ISOLATING THE OIL SWITCHES ON THE FLOOR ABOVE

13,800 volts, three-phase, for supplying power to Fern Hill substation, the Northern Pacific Railway Company's shops and other local consumption not within the range of economical distribution at 2300 volts. Automatic control of this bank is provided on the low tension side only by means of a type H, four-pole, motor-operated oil switch. Spare transformers for each of these banks are provided.

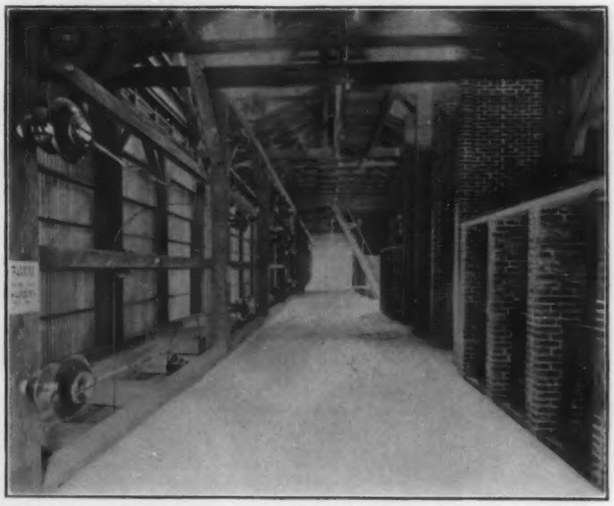
For receiving power from the 25,000-volt transmission line of the Puget Sound Electric Railway, four 200-kilowatt oil cooled transformers, wound for 25,000 to 50,000 volts, stepping down from 25,000 to 2300 volts, are installed.

The high tension oil switches are installed on a steel concrete gallery twenty feet above the transformer room floor, the two line oil switches on a gallery at right angles to the length of the building and the transformer switch on a gallery parallel to the length and along the north wall of the building. Directly under the transformer oil switch are the transformers themselves. On the opposite side of the room and parallel to its length and four feet above the floor are the transformer 2300-volt oil switches.

One 400-kilowatt induction regulator similar to those installed in the Massachusetts Street substation controls the potential of the supply bus, being installed between the transformer bus and the supply bus. Apparatus for cooling the transformer circulating water is being installed somewhat similar to that at the Massachusetts Street substation.

The 2300-volt power is used for lighting and power service in the city of Tacoma partly and partly converted into 600-volt direct current for railway and commercial motor service. This conversion is effected by two 500-kilowatt induction motor-generator sets, by one 850-kilowatt synchronous motor set and by 800 kilowatts in belted machines driven by a 1000-kilowatt synchronous motor. Either this synchronous motor or the 1000-kilowatt motor driving the 850-kilowatt direct current generator can be driven by the steam engines which drive

WIRE TOWERS, SHOWING THE HIGH TENSION TRANSMISSION LINE AS IT LEAVES THE POWER HOUSE

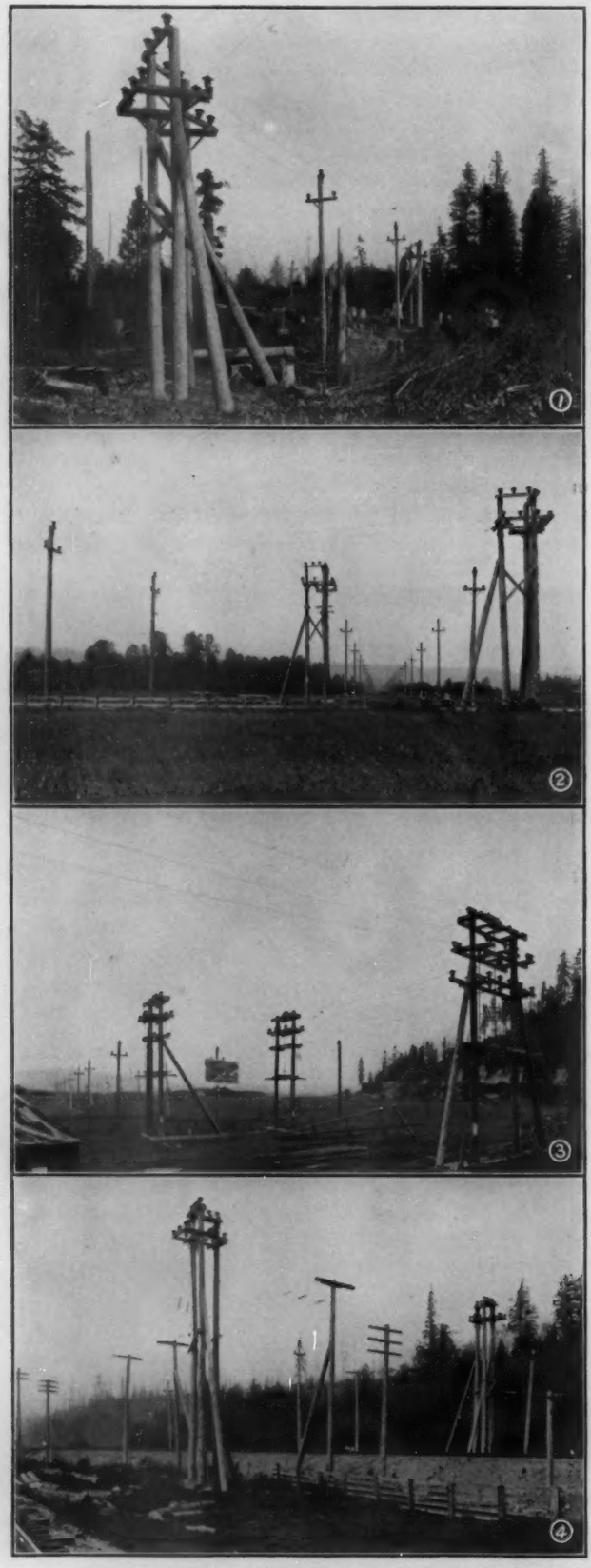


LONGITUDINAL VIEW OF THE FIFTH FLOOR OF THE SWITCH HOUSE, SHOWING HIGH TENSION SECTIONAL BUS TO LEFT, AND LIGHTNING ARRESTERS AND HIGH TENSION TRANSFORMER AND TRANSMISSION LINE SWITCH CELLS TO RIGHT

onto a line shaft in which these motors are set, being connected at either end by jaw clutches, thus furnishing a supplementary source of supply and reserve for any of the alternating current distribution, and for the induction motor-generator sets supplying current for the railway. A 100 horsepower induction motor furnishes power for driving a cable road accommodating the hill districts of the city.

The Tacoma Railway and Power Company operates about eighty-four miles of track in the city of Tacoma and between Tacoma and the neighboring towns of Puyallup, Spanaway and Steilacoom, and also furnishes power for the operation of the trains of the Puget Sound Electric Railway within the Tacoma city limits.

At the Fern Hill junction of the Puyallup and Spanaway lines is a steam station of 500 kilowatts capacity. There is being installed in this station a 500-kilowatt synchronous motor-generator set, supplied from the substation above described by a 13,800-volt transmission line.



1. A STANDARD CURVE CONSTRUCTION ON THE TRANSMISSION LINE
2. A RIGHT ANGLE TURN IN THE DOUBLE LINE AT ORTING
3. THE JUNCTION OF THE SEATTLE AND TACOMA LINES AT BLUFFS, SHOWING THE DISCONNECTING SWITCHES
4. WHERE THE TRANSMISSION LINES CROSS THE NORTHERN PACIFIC RAILWAY AT "THE MEADOWS"

THE MASSACHUSETTS STREET SUBSTATION, SEATTLE, SHOWING THE HIGH TENSION WIRING AND DISCONNECTING SWITCHES

THE MASSACHUSETTS STREET SUBSTATION, SEATTLE, SHOWING THREE OF THE SIX 2000-KILOWATT TRANSFORMERS

THE MASSACHUSETTS STREET SUBSTATION SEATTLE, SHOWING THE SWITCHBOARD AND COMPENSATORS

This same transmission line supplies current for the operation of motors and lights at the shops of the Northern Pacific Railway at South Tacoma and for the operation of induction motors driving air compressors working a Pohle air-lift system pumping water for the Tacoma city water supply, near South Tacoma, and for operating a large number of other stationary motors used by various manufacturing concerns.

The Puget Sound Electric Railway operates an interurban third rail system between Seattle and Tacoma traversing the White River Valley, a distance of thirty-six miles, and also a branch line reaching the town of Renton. Six-hundred-volt direct current is supplied to the third rail through three substations located at Georgetown, Kent and Milton.

Each substation contains a bank of transformers stepping down from 25,000 volts, three-phase, to 2300 volts, two-phase; also a 300-kilowatt induction motor-generator

THE MASSACHUSETTS STREET SUBSTATION, SEATTLE, SHOWING THE REGULATORS AND LOW TENSION SWITCH CELLS

set and a storage battery having a rating of 384 kilowatts on the hour basis. Oil switch control is provided on both the high and low tension sides.

From Kent substation is operated the city lighting systems of Kent and Auburn, a transformer, separate from those feeding the motor-generator set, being provided for supplying this 2300-volt service.

These substations are supplied from the 25,000-volt transmission line previously mentioned, this line having the 25,000-volt transformer relay at both the Seattle and Tacoma ends. When this line is operated at 30,000 volts, transformers for this voltage will be installed in all the substations.

The electrical development has been designed primarily to insure uniform and uninterrupted service. Continuity of service has been insured by the greatest solidity of construction in every part; by duplicate busses and switches at the power house; duplicate transmission lines and spare transformers at each end of the transmission line so that all repairs can be made without discontinuing service, and by having in all the electrical machinery an overload capacity of from 25 per cent. to 50 per cent.

In addition to this there are in reserve in Seattle and Tacoma six steam plants of 10,000 kilowatts aggregate capacity and six storage batteries of 2700 kilowatts aggregate capacity, all electrically interconnected with each other and with the water power plant, and ready for supplementary and relay service.

THE PELTON WATER WHEEL EQUIPMENT IN THE PUGET SOUND POWER COMPANY'S PLANT.

BY GEO. J. HENRY, JR.

AT the time the order was placed for Pelton water wheel apparatus for this installation, there were no tangential wheels in operation anywhere in the world driving anything larger than a 2000-kilowatt generator.

The problem presented for this plant was to equip the initial installation with four direct connected units each driving a 3500-kilowatt General Electric generator at 225 revolutions per minute, the water wheels to operate under an effective head of 865 feet. Also two Pelton exciter water wheels, each driving a 150-kilowatt exciter at 600 revolutions per minute. The problem involved in designing the wheels for this installation were largely new, not that wheels had not been built for satisfactorily withstanding higher pressures, as numerous Pelton wheels are in satisfactory operation up to 2200 feet, but that the enormous strain coming on the buckets and wheel rims was vastly greater than anything that had before been attempted in this line. The strain on the shaft and bearings was also to be well above all recognized practice. The typography of the ground on which the power house was to be located was such as to make it necessary to maintain a minimum width of building, otherwise the amount of excavation necessary would have been enormously expensive.

The ultimate installation is to consist of eight units, and the entire equipment is so arranged as to provide complete pilot control of the water wheel apparatus as well as the electric. This is accomplished from the switchboard which is arranged at one end of the building, and the complete eight units, the ultimate proposed capacity, will require a building length considerably over 200 feet long. It was therefore necessary to keep down the length of each unit as much as possible, and for this reason, among others, it was decided to employ the Pelton two-bearing double wheel overhung type of construction. This was arranged with one water wheel on each end of the main shaft, this construction enabling the bearings to be more equally loaded than if the entire output was placed on one water wheel. The fractional load efficiency is also better, and the regulation very much closer than would be obtained if a single nozzle and wheel were employed to develop the entire output for each unit.

As described elsewhere in this issue, each main unit and exciter is supplied by a separate pipe line conducting water from the balancing reservoir at the inlet end of the flume line.

The contract with the Pelton Water Wheel Company for the hydraulic equipment commenced at the terminals of

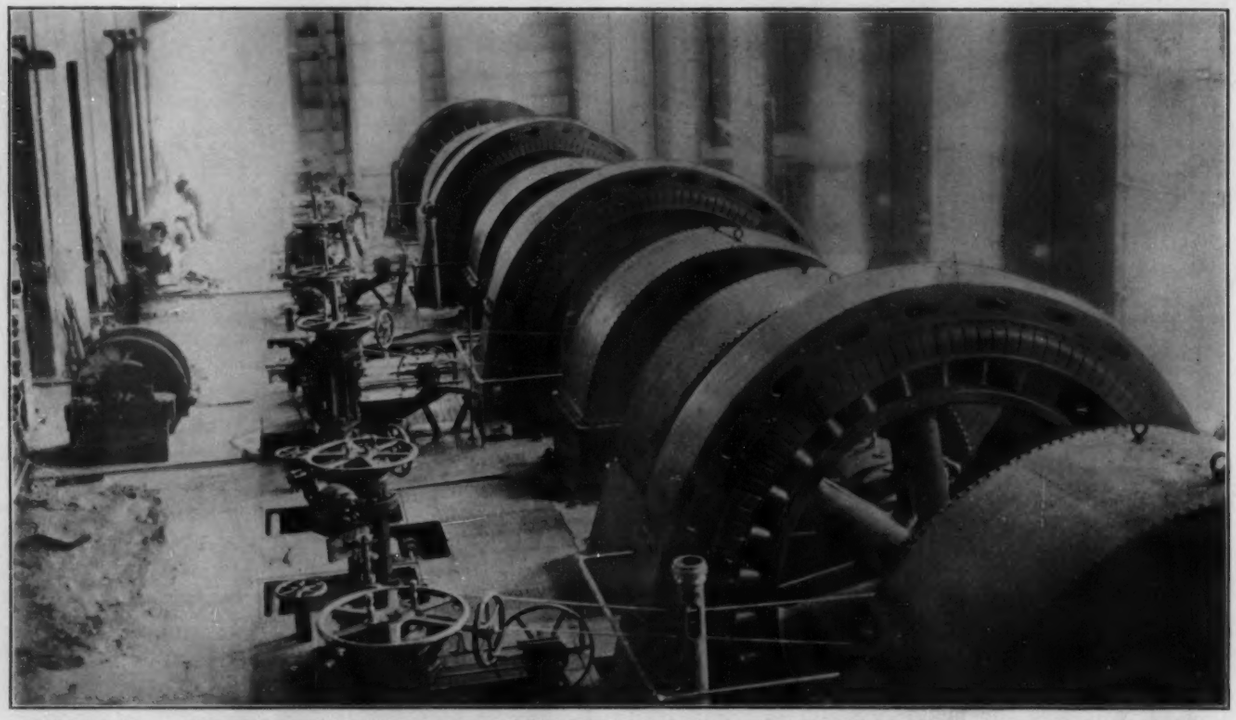
these four main pipe lines and that of the exciter line, and beginning at this point is located a heavy cast steel Y pipe. This is cast with extra large ribs and with heavy flanges. Each is faced and recessed for suitable rubber gaskets. Each branch of this Y pipe feeds to a twenty-four-inch inside diameter, connecting pipe flanged to match the inlet of main gate valves (see Dravings 1 and 2 showing elevation and side view of the main units).

The supply for each of the eight Pelton water wheels is furnished through a twenty-four-inch cast steel specially designed gate valve, as illustrated in Photograph No. 2.

The main bodies of these gates are located below the floor line, the yoke and gearing projecting well above to enable the gates to be readily handled by hand from the main floor if necessary. The main screw consists of a nickel steel stem threaded with four left-hand square threads per inch, running in a phosphor bronze nut. Loosely threaded to this nut is a thirty-six-inch polished rim hand wheel with clutch mechanism. This hand wheel is to enable the gate to be quickly opened when the pressure is equalized on each side of the main gate disc by the use of the by-pass. Suitable gearing is arranged so that the gate may be started on its seat under the full working pressure by an auxilliary hand wheel, shown in the illustration. An electric motor control with suitable switching mechanism from the main switchboard is also provided for operating the valve.

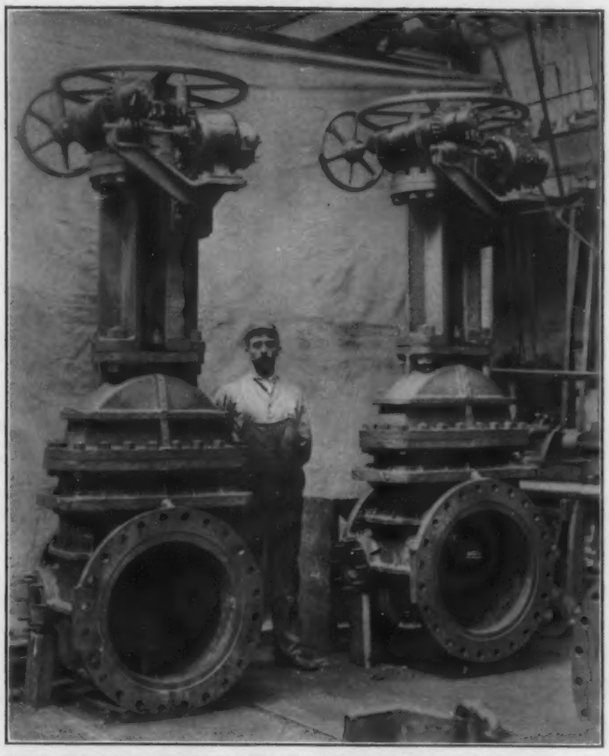
There is mounted on the main gate stem a cut-out to enable the motor to automatically cut-out at each end of the stroke without interfering with the return connections and the motor being reversed the cut-out is again automatically cut-in.

The gate seats are made very heavy, of the highest grade phosphor bronze, faced and ground in place. They are readily renewable, as are also the gate discs, should this become necessary. There is arranged for each gate a five-inch by-pass of similar design throughout, the hand wheel for operating this projecting above the main floor line. By closing the needle nozzle and opening the by-pass, pressure is equalized around the main gate valve, which can then be very easily and quickly opened, or the main gate may be controlled entirely from the switchboard by the electric motor drive clearly shown in the illustration. The enormous pressure on the nut, this being over 200,000 pounds, is taken up in each direction by a suitable oil-packed steel roller bearing. These are arranged on each side of the bronze nut collar. The nickel steel gate stems are provided with suitable bushings to enable them to be packed under full working pressure, thus reducing the likelihood of having to empty the main pipe line to a minimum. The outlet flanges of these main gates are connected to the inlets of the ball and socket jointed needle nozzle; one nozzle being provided for each water wheel. A small curvature is introduced in these nozzles to serve the double purpose of an elbow, which is necessary to reach the water wheels from the Y, and to provide a suitable outlet for the operating stem of the needle.



PHOTOGRAPH NO. 1. INTERIOR OF STATION ON AUGUST 3, 1904, SHOWING FOUR 3500-KILOWATT, 225 REVOLUTIONS PER MINUTE GENERATORS, DRIVEN BY PELTON WHEELS. MAXIMUM CAPACITY OF EACH UNIT 7500 HORSEPOWER, WHEELS OPERATING UNDER 865 FEET HEAD

The deflecting nozzles are of very substantial proportions, having twenty-four-inch inside diameter inlet flanges and tapering slightly to the tips. The ball joint is polished and provided with sole leather packing. The trunnion pins are each set in oil packed phosphor bronze bushings and are of fluid compressed nickel steel



PHOTOGRAPH NO. 2. THE CAST STEEL MAIN WATER WHEEL GATES OF PELTON TYPE THESE ARE OF SINGLE DISC, OUTSIDE SCREW AND YOKE FLANGED TYPE, WITH QUICK AND SLOW MOTION GEARING AND WITH AUXILIARY MOTOR DRIVE AND BY-PASS

turned and polished. Supports are provided on each end of the trunnion pins, one end setting in an axial recess in the ball and the other end supported by a heavy forged steel strap. This is securely keyed and bolted to the body of the nozzle. The swinging portion of the nozzle weighs approximately 5000 pounds, and is counterbalanced by a suitable bronze lined controlling hydraulic cylinder with leather packed piston receiving pressure from the main pipe line. The nozzle tip is flanged and bolted to the terminal of the nozzle taper pipe, and turned true and polished on the inside surface to curves of least resistance. The needle itself is cast hollow and of gun metal, and turned true and polished to make the smoothest possible surface over which the water flows.

The accompanying photograph (No. 4) shows the character of stream obtained from one of these nozzles. This photo also clearly shows the blur occasioned by the rotating wheel center and buckets during the exposure of the photographic plate.

The needle is threaded to the end of a heavy nickel steel rod which is carried in a suitable grease-packed bushing and is supplied with bronze bushed bearings. The water pressure against the needle is balanced by helical steel springs, which may be adjusted to the different sizes of tips or to wear. The position of the needle may be readily adjusted by a hand wheel actuating cut gears and forged steel connections to the needle stem.

It will be noticed that the power developed on each wheel may be controlled in two different ways:

First—By deflecting the nozzle, thus varying the quantity of water which impinges on the wheel; and

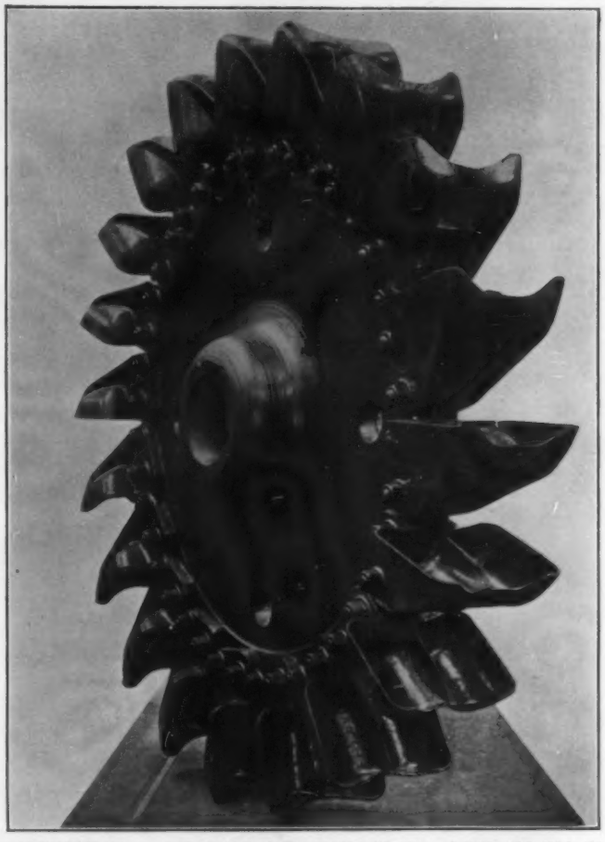
Second—By varying the flow of water through the nozzle by adjusting the position of the needle above mentioned.

The hydraulic governor is arranged for controlling the speed automatically by moving the deflecting end of the nozzles. It will be noticed that this in no way varies the velocity of water flow in the main pipe line, and therefore cannot possibly occasion any water hammer. This is a point of the utmost importance in obtaining accurate regulation, especially under high pressures and when using long pipe lines. This form of regulation is much superior to that obtainable with turbine wheels for this very reason.

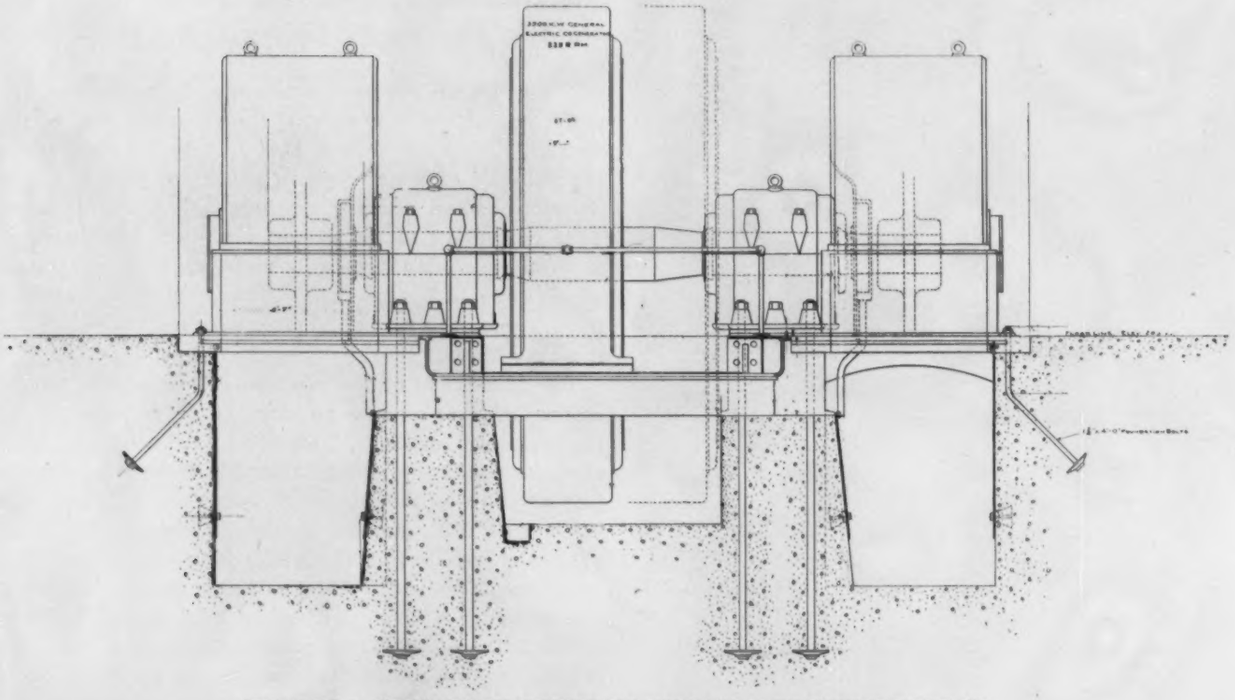
The adjustment of the position of the needle can be accomplished as often as required in order to allow for the peak load, which is likely to occur during any hour of the day or during different periods of the year, such as holiday loads on the interurban railroads.

The hydraulic governor is arranged between the main gate valves and nozzle, and a suitable rock shaft, and the gear connections control the pair of nozzles for each unit. The governor is driven by belting from the main shaft.

The Pelton wheels, two in number for each unit, are pressed one on each overhanging end of the nickel steel shaft. These are nine feet ten inches in diameter and each wheel is fitted with a set of cast steel annealed Pelton buckets ground to true interior surfaces and milled and drilled to United States standard gauges to fit the rim of the main



PHOTOGRAPH NO. 3. ONE OF THE MAIN PELTON WHEELS. THERE ARE TWO OF THESE FOR EACH UNIT, EACH WEIGHING OVER 14,000 POUNDS, AND ONE PRESSED ONTO EACH END OF THE NICKEL STEEL SHAFT



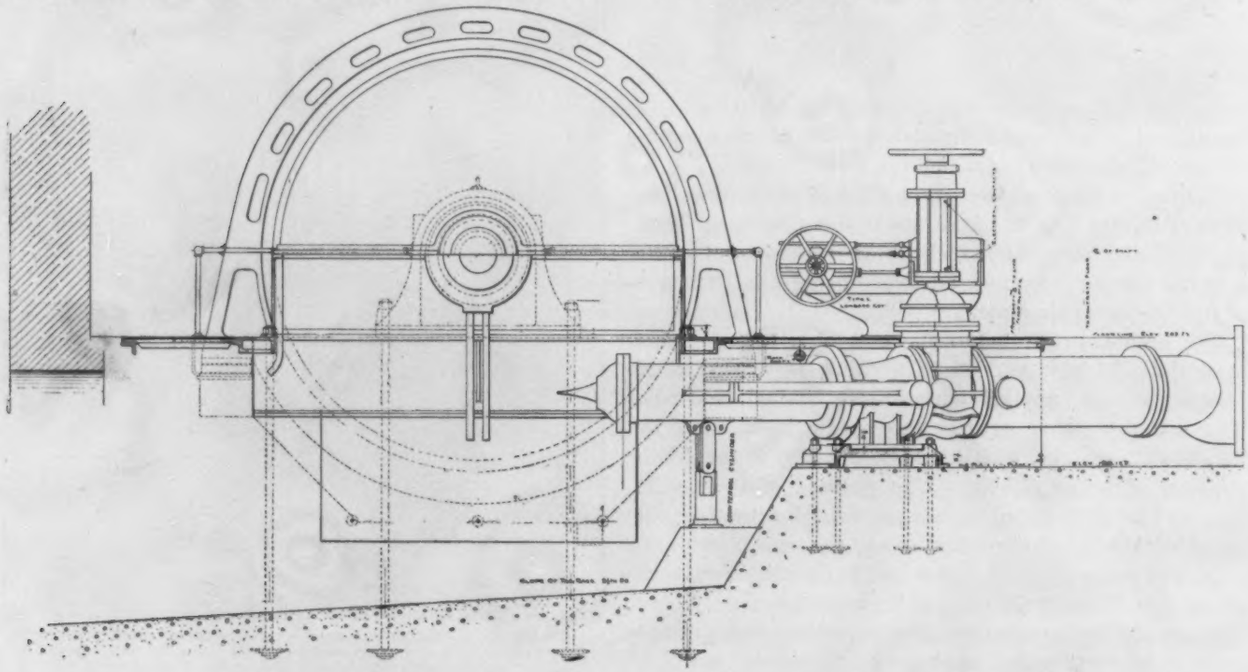
DRAWING NO. 1. SHOWING THE END ELEVATION OF A SINGLE UNIT OF THE PUYALLUP RIVER PLANT

cast steel wheel center. Buckets and centers are carefully adjusted to an exact weight and to a running balance, and each bucket is securely bolted to the wheel rim with two fluid-compressed nickel steel bolts provided with hexagon semi-finished nuts. The buckets are spot faced where the nuts seat upon them, and all milling and drilling and reaming is done to United States standard gauges and jigs.

The main shaft for each unit is made from highest grade fluid-compressed nickel steel, forged hollow, annealed and bored out. The shaft is turned to fourteen inches in diameter at each end and to twenty inches in diameter where fitted with the General Electric rotor between the journals (see Photograph No. 5).

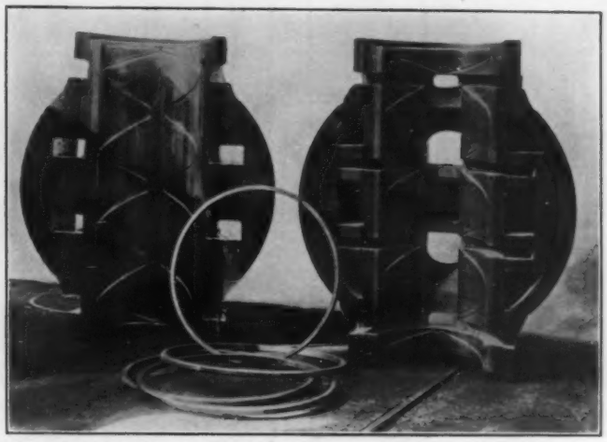
The journals are sixteen inches in diameter and are supported by a babbitted surface forty-eight inches long. The journals are polished and oil guards are arranged on each end with a liberal right angle surface bearing on a suitable babbitted projection to take up any end thrust that may occur due to the machine getting out of magnetic balance or alignment.

The General Electric rotors were pressed onto the main



DRAWING NO. 2, SHOWING THE SIDE ELEVATION OF A MAIN PELTON UNIT IN THE PUYALLUP RIVER PLANT

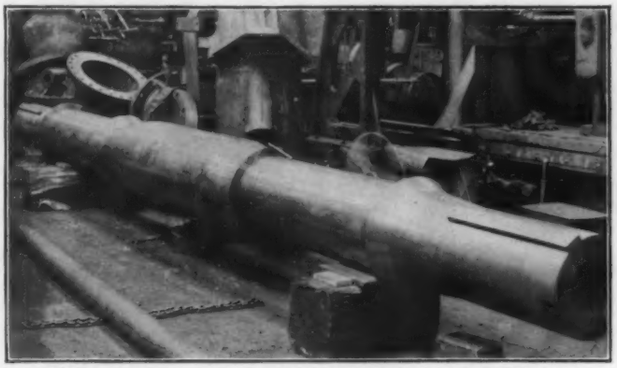
PHOTOGRAPH NO. 4. NEEDLE NOZZLE STREAM. SHOWING THE STREAM OF WATER FROM A PELTON NEEDLE REGULATING NOZZLE



PHOTOGRAPH NO. 8. SHOWING BABBITTED SURFACES WITH OIL GROOVES FOR HIGH AND LOW PRESSURE OIL AND BALL JOINT

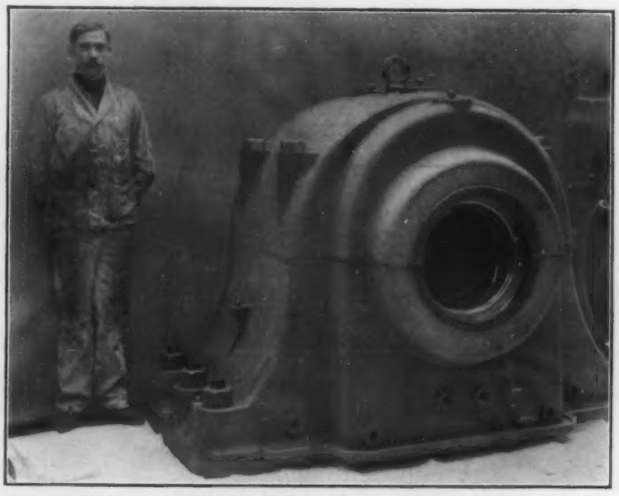
shaft with a pressure of about 150 tons, and each water wheel was pressed on with a pressure of between 90 and 110 tons.

The bearings are of Pelton generator type of construction, with heavy machined ball and socket joints, and provided with Finn's armature metal, bored out and scraped, and each supplied with four heavy bronze rings. In addition to this, special oil grooves are cut in both the top and bottom halves of the bearing, which are further doweled together. There is a special high pressure oil groove not connecting with any of the others. This is located vertically under the axis of the shaft, and connection is made to this by flexible high pressure oil pipe from a motor-driven high pressure oil pump supplying pressure oil at 2000 pounds per square inch. It is only necessary to use this pump in starting the wheels in order to avoid damaging the babbitt surface, as the rotating element weighs in excess of 98,000 pounds. So nicely is the entire rotor balanced that a man's weight on one of the buckets will readily turn the entire shaft when the high pressure oil is turned on. In addition to this, there is provided a centrifugal oil circulating system so that the bearings may be flooded with a large additional amount of cool oil if the least heating occurs.

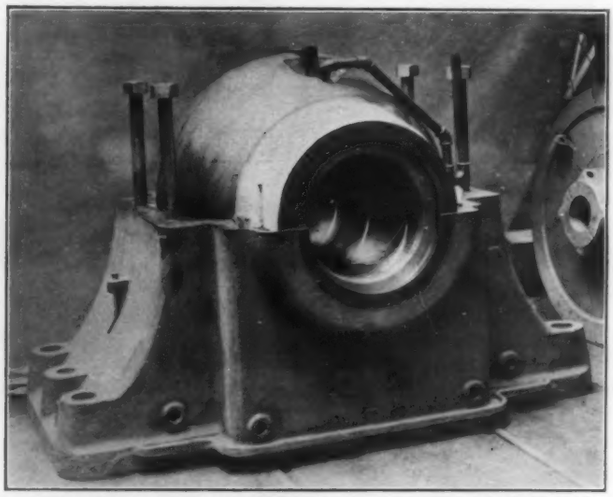


PHOTOGRAPH NO. 5. ONE OF THE HOLLOW FORGED FLUID COMPRESSED NICKEL STEEL SHAFTS USED IN THE PUYALLUP RIVER PLANT

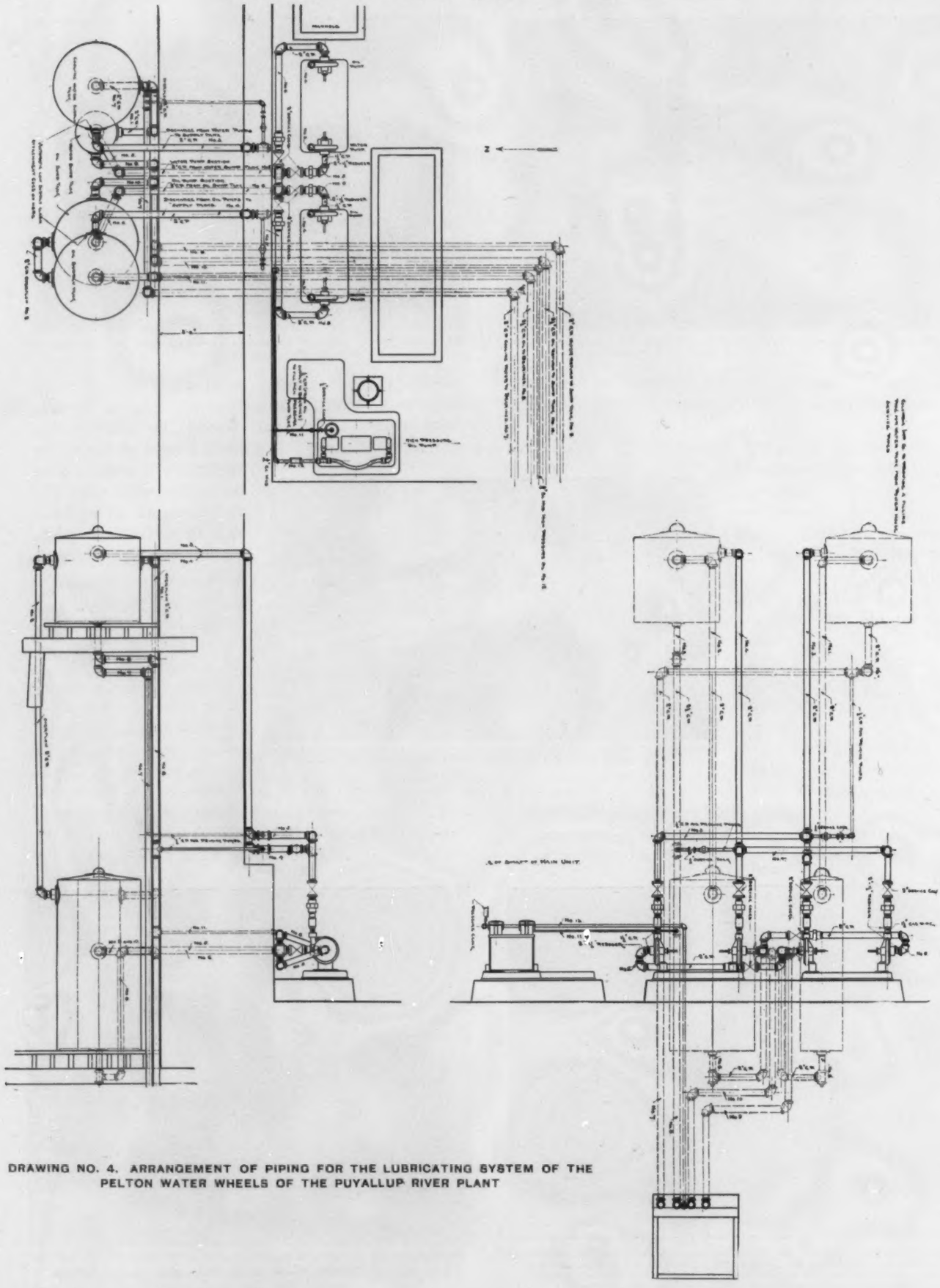
There is also a set of water cooling connections arranged to a grilled water compartment next to the babbitt surface so that a maximum amount of heat may be removed by the cooling water. In each bearing a pair of thermostats is connected in parallel in a suitable electric circuit for indicating at the switchboard a dangerous temperature rise in any of the



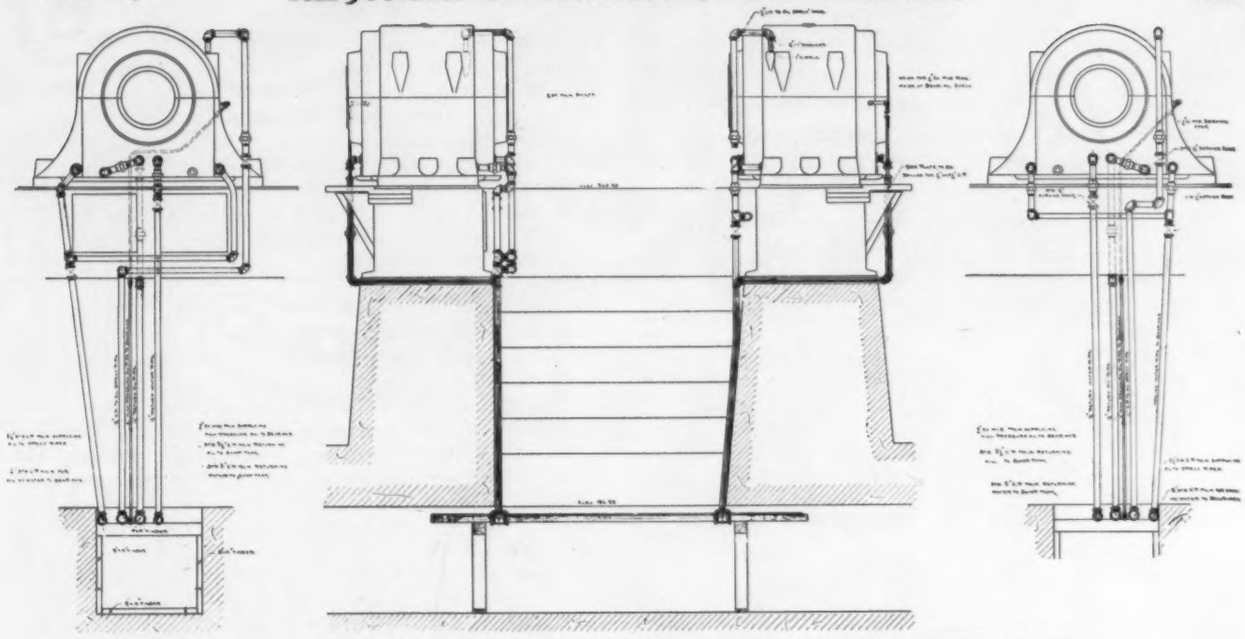
PHOTOGRAPH NO. 6. SIXTEEN-INCH BY EIGHTEEN-INCH PELTON GENERATOR TYPE BEARING WITH MACHINED BALL AND SOCKET JOINT; WATER COOLED, AND WITH CENTRIFUGAL AND HIGH PRESSURE OIL CIRCULATION. DESIGNED FOR CARRYING WEIGHT OF 66 500 POUNDS AT 225 REVOLUTIONS PER MINUTE



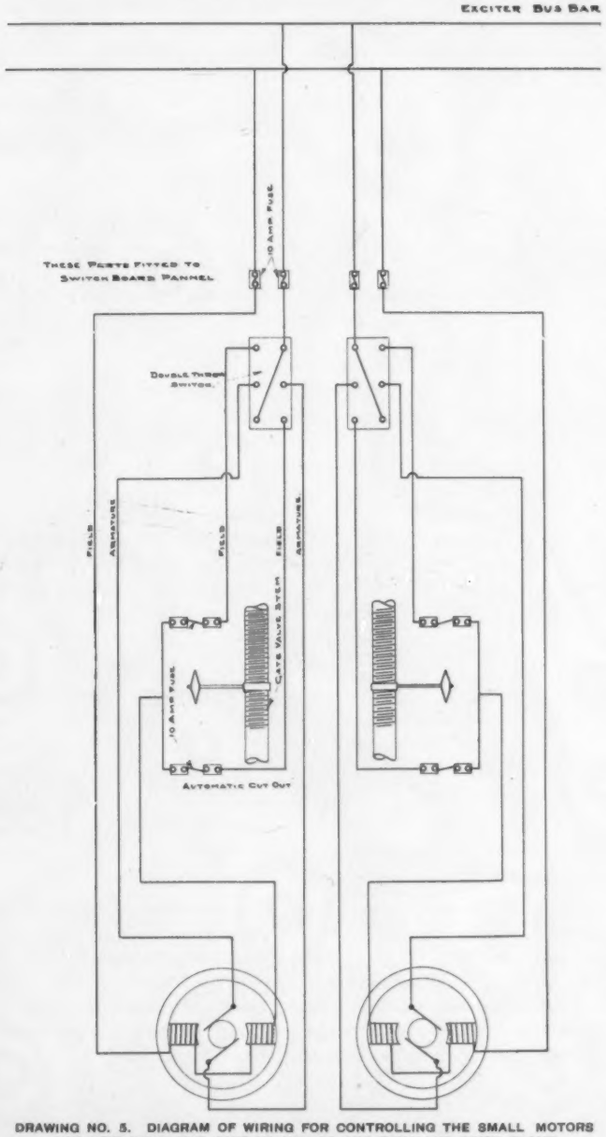
PHOTOGRAPH NO. 7. BEARING PARTLY ASSEMBLED SHOWING COLLAR SURFACE OF BABBITT, OIL SUPPLY PIPE AND WATER AND OIL CIRCULATION AND HIGH PRESSURE CONNECTIONS



DRAWING NO. 4. ARRANGEMENT OF PIPING FOR THE LUBRICATING SYSTEM OF THE PELTON WATER WHEELS OF THE PUYALLUP RIVER PLANT



DRAWING NO. 3. ARRANGEMENT OF PIPING FOR THE HIGH PRESSURE OIL, THE LOW PRESSURE OIL AND WATER SYSTEM



DRAWING NO. 5. DIAGRAM OF WIRING FOR CONTROLLING THE SMALL MOTORS FOR OPERATING THE GATE VALVES OF THE PUYALLUP RIVER PLANT

journal bearings. The water wheel is encased in a sheet steel cover housing matching the heavy cast iron lower housing, which in turn is carried on a massive cast iron bed plate. This bed plate is provided with water grooves and extends beneath the engine type generator, which it also supports, thus making one bed plate for each generator.

Polished brass hand-rails are supplied around each generator and heavy sheet steel grilled floor plates are provided over the nozzle gate and rock shaft compartment for each unit. The removal of these plates permits access to the various pressure connections and enables all of the heavy parts to be readily handled with the power house fifty-ton electric crane, which is arranged to travel the full length of the building.

There are two exciter units, either one capable of exciting six of the main generators. These are driven by a special thirty-eight-inch Pelton wheel supplied with water through a combination needle deflecting nozzle, and the wheel is encased in a heavy cast iron and sheet steel housing and carried on a suitable cast iron bed plate, which is also arranged to carry the exciter and induction motor.

The highest grade of material and best possible machine work was furnished throughout on this plant, which has now been in operation for some time past. No shut down of any kind has been occasioned by the hydraulic apparatus, although each unit is guaranteed to operate at 7500 horsepower, and has in practice carried loads in excess of that amount.

The plant is operated twenty-four hours per day, and owing to the obstacles encountered in the design and installation it is certainly a credit to Messrs. Stone & Webster, of Boston, as well as the others engaged in the design and actual construction work, as the entire project has been carried through to a successful issue in the remarkably short period of sixteen months, the first water wheel unit being put in continuous operation in exactly one year from the signing of contract.

The entire hydraulic equipment from the terminal flanges of the pipe lines to the engine type generators, including all the governing apparatus, shafts, bearings, bed plates, etc., were designed, manufactured, erected and put into operation in the power house by the Pelton Water Wheel Company, of San Francisco.

Test of samples taken from fluid compressed hollow forged nickel steel main shaft:

Shaft	Tensile Strength	Elastic Limit	Per Cent. Extension	Per Cent. Contraction
1	81,490 lbs.	53,980	28 5	56.44
2	80,970 "	50,420	29	59.79
3	80,970 "	50,420	27	60 3
4	80,470 "	50,930	26.5	50.14
Requirements	80,000 "	50,000	25	45

Tests of nickel steel rods:

Tensile strength	95,000	102,000
Elastic limit	65,000	65,500
Extension, per cent	23%	24.2%
Contraction, per cent		53.9%

FLOW OF GAS IN PIPES UNDER PRESSURE.

BY A. M. HUNT.

THE following formula is given by Robinson in the *Progressive Age* of March 16, 1903, for the flow of gas:

$$F = 48.4 \sqrt{\frac{d^5}{L}(P_1 + P_2)(P_1 - P_2)\frac{0.6}{g}}$$

Where F = cubic feet per hour at atmospheric pressure

d = diameter of pipe in inches,

L = length of pipe in miles,

g = specific gravity of gas,

P_1 and P_2 the absolute pressure in pounds per square inch at the two ends of the pipe.

If the specific gravity is assumed to be 0.6 the formula may be written

$$F = 48.4 \sqrt{\frac{d^5}{L}(P_1^2 - P_2^2)}$$

The curves presented on the opposite page give the solutions of this equation for a one-inch pipe from one-tenth of a mile to one mile long, and by using coefficients results may be obtained on pipes up to twelve inches in diameter and 100 miles long.

Example: How many cubic feet per hour will flow through a four-inch line thirty miles long, pressure at entrance fifty pounds absolute, and terminal pressure twenty pounds absolute?

$$P_1^2 - P_2^2 = 2500 - 400 = 2100$$

On the lower axis find this point, follow vertical line to curve of three-tenths of a mile and then horizontally to the vertical axis, which gives 4050 cubic feet as amount that will flow through one-inch pipe three-tenths of a mile long. From table of coefficients, the multiplier for four-inch pipe is 32, and for 100 times the distance 0.1, or amount through four-inch pipe under given conditions will be $4050 \times 32 \times 0.1 = 12{,}960$ cubic feet per hour.

EARLY SAN FRANCISCO STREET RAILROADS.*

IN 1857 the only regular line of public conveyance in San Francisco was the "Pioneer," or "Red 'bus" line, making half-hourly trips from the Plaza on Kearny street to the Nightingale hotel at the Mission Dolores. Its route ran along Kearny—then a narrow street—down Third to Mission, out the Mission toll road to the hotel located at the corner of Mission and Center —now Sixteenth—streets. The rate of fare was 10 cents on week days and 25 cents on Sundays, except to regular patrons. Later on the "Yellow 'bus line" was started. This line ran from the Plaza and reached the Mission via Folsom street. With a half-hourly service only, and a daily express delivery of once a day, the Mission was further away in point of time and convenience than, at this writing, are Oakland and Alameda, eight miles distant, and San Mateo, twenty-one miles away.

In May, 1859, ground was broken for the original Market-street road, and on July 4, 1860, the line was formally opened. It was an occasion of great rejoicing, and the train (it was originally a steam motor road) was received with cheers by the population that had turned out to celebrate the occasion. The road was three miles in length. Trains were run from 6:30 A. M. until 10:30 P. M The fare was 10 cents.

Where the New City Hall now stands was the Yerba Buena Cemetery, which was approached over Mission street (then a toll road) and Seventh (then Price street), which is in front of the new Postoffice site.

Along the entire line of Market street, from Hayes Valley to Third street, was a succession of sand hills in 1859. One of the largest was in front of the now famous Blythe Block at Third street. After these hills were cut through by an open cut and the railroad started, much trouble was experienced in keeping the sand off the track. The cutting, for economy's sake, was narrow, and as the sand dried in the embankments it slid down and covered the track. These difficulties were finally overcome by the use of "brush" or scrub oak, which was utilized as a sort of thatch that covered and held the sand. At first the road terminated at Sixteenth (then Center street), but later, when Pioche & Bayerque got possession of the "Willows," a then famous suburban garden, it was extended to a little beyond Seventeenth street, to the entrance of the "Willows."

About the some time the Hayes Pavilion, at Hayes Park, on Laguna street, was erected, and a branch road along Hayes street to Laguna street, was consructed. On week days this branch was operated by a one-horse car, but on Sundays and holidays the steam dummies with their cars ran up to the Pavilion.

At the time the road was built Hayes Valley was rented to Italian gardeners, who raised large quantities of vegetables there. The block upon which the St. Ignatius Church and College now stand was the residence of Thomas Hayes, the founder of the road. Upon the adjoining block south resided James Van Ness.

At this time there were but four or five dwellings in Hayes Valley, and between that and the city proper but a single habitation, owned and occupied by Paul Rousett, a very worthy French gentleman, who subsequently died in his native country. That picturesque cottage stood near Market street, at its junction with Turk street. The road had some memorable features. Its roadbed along the center of the street, from California to Third streets, being in an open cut, below grade, was called "McCoppin's Canal," in which, during the rainy season, many worthy citizens narrowly escaped drowning. The only opening along Market street, west of Third street, was upon the line of the railroad. Such was Market street in those days, and the property fronting upon it was considered of small value.

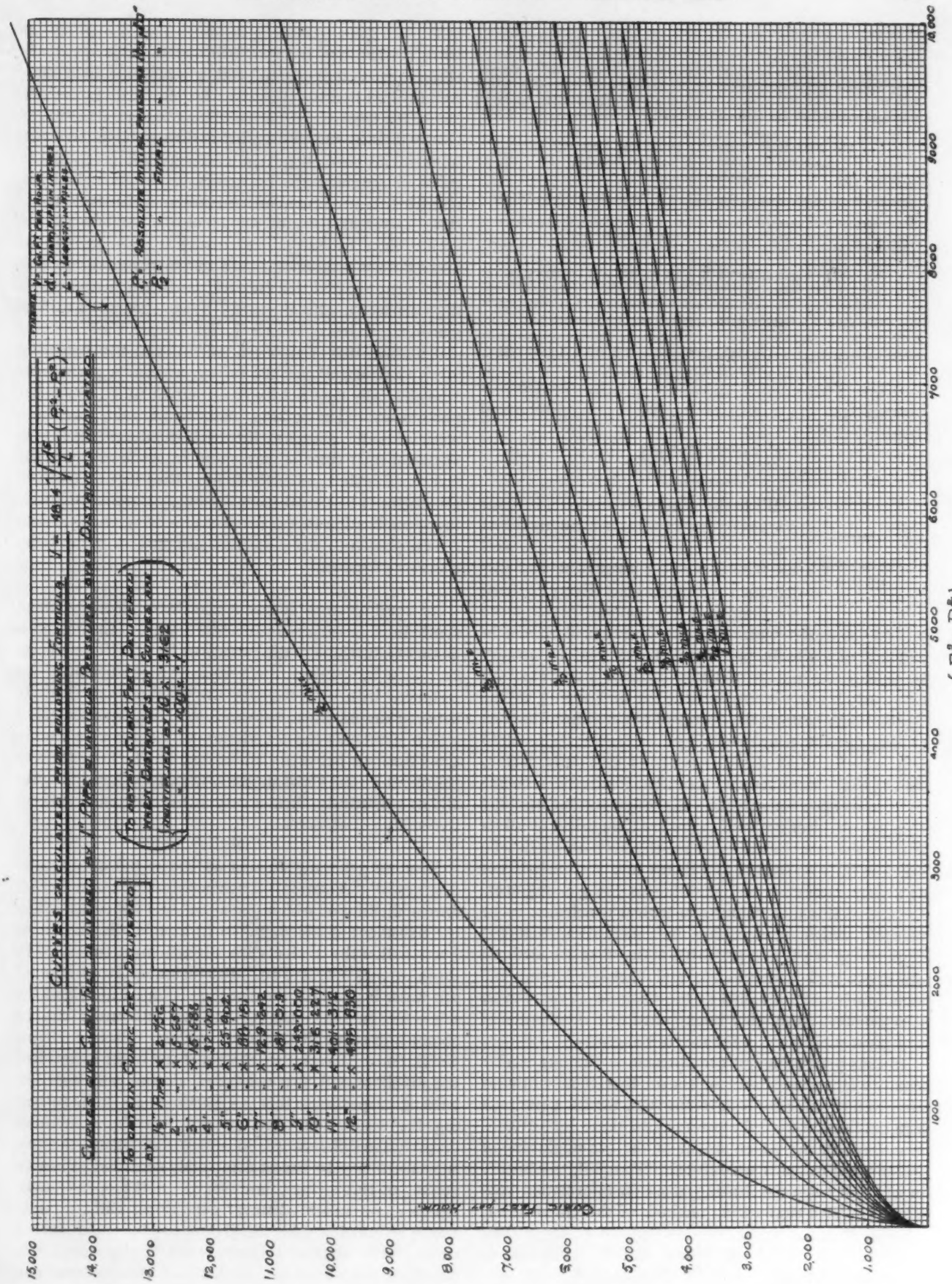
*From *Transit Tidings*, San Francisco, September 1, 1904.

PERSONAL.

Mr. I. B. Funk, formerly in charge of the electrical department of the Madison Mercantile Company, has taken a position in the sales department of the Nernst Lamp Company, San Francisco district office.

Mr. William A. Doble, president of the Abner Doble Company, San Francisco, is at St. Louis in the performance of his duties as a member of the International Jury of Awards, in the Department of Machinery, of the Louisiana Purchase Exposition.

Dr. W. F. Durand, late professor of mechanical engineering of Sibley College, Cornell University, Ithaca, N. Y., has been appointed head of the engineering department of Stanford University, vice Dr. W. W. Smith, who has presided over the engineering department of Stanford from its inception, and who resigned therefrom in order to accept the position of Dean of the Sibley College, thus trading places with his successor.



CURVES FOR DETERMINING THE FLOW OF GAS IN PIPES UNDER PRESSURE—SEE PAGE 424

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EDITORIAL.

THE FOUNDATION OF TAR

With the single exception of water works engineering, there is no branch of quasi-public service in more universal use than that of the generation and distribution of artificial gas. Every civilized community of any material consequence has its gas works, which as a rule fore runs electricity in the bulk of the business transacted, and gas engineering is among the oldest of these kindred industries, yet singularly if there is any institution of learning in the world which bestows the degree of gas engineer, that fact is not generally known—perhaps the nearest approach to it is to be found at the University of California, which, during the present summer term, has instituted a course of lectures upon the subject. Let us go further and say that gas engineering itself is the most empirical of all its fellows, for as a class there is no engineer on earth who relies so little on science and theory and so much if not so utterly on custom and tradition as the gas engineer. In view of this there is but one logical conclusion to be reached, which is, speaking in generalities, that gas engineering is yet in a primitive state, that its methods are crude and undeveloped, and that considering the amount of capital invested in the business it represents, it is the most thoroughly unexploited and unscientific of any great profession on the face of the globe.

In thus presenting our compliments to the gas profession, we fain would have it known that these criticism are given in the most benevolent vein, for as a progressive publication we feel a paternity to those industries—prominent among which is that of the gas engineer—to which these columns are devoted. To uplift, to educate, in fact to become the clearing house for information concerning refined engineering methods of the Great West, whether they pertain to gas, electricity or power in their concrete forms, is the ambition of THE JOURNAL—an ambition which it will attain at all costs.

Though gas engineering is by no means a profession without literature, it certainly is one without systematic research. Were it otherwise it would abide in a more well ordered house. To illustrate: electricity is the subject of the most exact science known to man, its units are clearly defined and thoroughly understandable, its functions are all worked out in mathematical precision, in point of accuracy the measurements of its values are absolutely beyond compare, and its standards are immaculate. Given an electrical appliance of a fixed design and (other than in exceptional cases) it will perform its allotted duty without reference to the personal equation of its operator, and this duty will be done at an extremely high efficiency. As much can by no means be said of gas—that industry which is an innocent of absolute standards as it is of high efficiencies, and the operation of which depends upon the skill or whim of a *genus homo* who generally does not know a thermal unit from a bar photometer. Gas making methods of today are both wasteful and primitive, for with whatever lustre the names of their votaries may shine in its firmament, the fact remains that gas methods have thus far not received the degree of universal scientific and theoretical engineering specialization that is necessary to bring them to any near approach to the perfection attained in other more complex processes.

By specialization is meant the thorough analytic and synthetic discussion of a particular feature of the business, be that feature one of the process or be it with reference, say, to a by product. Where is the gas operator, for instance, who comprehends the distinctions that lie between simple, fractional and distructive distillations, or who understands the foundation of tar, or who knows the differences between coal tar and the tars made from petroleum? Yet these subjects, whether taken individually or collectively, form a very interesting and instructive study. Let us see:

Tars are generally defined as the liquid products of destructive distillation. Destructive distillation is that form of distillation which gives products not contained in the substance distilled, while in simple distillation or fractionation the products are all such as are contained in the substance operated on. For instance, if a solution of salt water is distilled, the distillate is pure water, and the salt is left behind; nothing but salt and water can be obtained in either distillate or residue: this is a simple distillation. If a mixture of alcohol and water is distilled, the distillate will also consist of alcohol and water in varying proportions; this is a fractionation, as by repeating the distillation often enough, and by combining properly the different fractions of the distillate, the two substances may be almost completely separated. But in neither of these cases, however often the operation be repeated, or under whatever conditions, will any substance be found in either distillate or residue which did not exist in the original mixture. But if, for instance, a sample of bituminous coal be distilled, the products will

be: gas, various oils and acid bodies. water, pitch and coke. None of these substances (except part of the water) are to be found in the coal, nor is is any substance resembling coal found in any of the products. This is a destructive distillation, because the coal is completely destroyed, in being changed into other substances.

All solid organic substances of complex natures—coal, wood, solid fats and waxes, and asphalts, and many liquids, such as petroleum and the animal and vegetable fats and oils, are subject to destructive distillation, and, strictly speaking, all these substances yield tars; but the word tar is ordinarily restricted to such of these products as are heavy, black and viscous, the limpid and lighter products, such as those from fatty oils, being called by other names. From a commercial point of view, the only important tars are those given by coal, wood and petroleum.

Wood tar could not be mistaken for either coal or oil tar by the least experienced, as it differs radically from either in all its properties. It is generally of a brownish color, instead of black. It has a strong smell of burned wood, instead of the characteristic (but indescribable) odor of gas tars. When shaken up with water it is strongly acid to test papers, while coal tar will almost always be alkaline, and oil tar almost always neutral. It contains large quantities of phenols (which, however, are entirely different chemically from those of coal tar), but no naphthalene. The pitch is brownish, translucent in thin layers, and has a strong resinous odor, while gas tar pitches are grayish to jet black, very dense, and have a slight sharp odor.

Coal tar will be alkaline if it contains ammonia, as is generally the case. Ammonia always accompanies fresh coal tar, but may evaporate on standing. It is perfectly safe to say that a tar which gives an alkaline reaction when shaken with water and tested with litmus is a coal tar, but it is only probable that a tar which is neutral to litmus is an oil tar. Coal tar may be certainly distinguished from oil tar by distilling off and condensing the oil, and shaking up the latter with a quarter of its bulk of caustic soda solution of 10 per cent. strength. The soda solution is separated, filtered through cotton until perfectly clear, and neutralized in a graduate with hydrochloric acid. If the oily layer of phenols which comes to the top in a few minutes is greater than 1 per cent. of the volume of the oil, the tar is a coal tar, if less, the tar is from petroleum. Coal tar oils generally give from 10 per cent. to 40 per cent. of phenols, oil tars seldom more than a trace. If the oil shows a tendency to crystallize, it must be kept melted while the soda treatment is being applied. The appearance of tars from coal and oil is identical, and the difference in odor, while chasacteristic, is so slight as to be apparent only to an expert.

Petroleum is decomposed almost completely at a very high temperature, but very much less at its boiling point. The heavier portions of the crude also decompose much more readily and completely than the lighter parts. If a a light crude oil, containing gasoline, is distilled under ordinary conditions, the gasoline will pass off unchanged, the kerosene will be slightly decomposed, the middle portion of the oil still more so, while the highest boiling parts of the oil (the heavy lubricating oils) will be almost completely altered unless special precautions are taken. But all the products of such a distillation will be relatively limpid and light colored. If we passed the oil, not into an ordinary still but into an iron retort heated to dull redness, all parts of the oil except the lighter gasolines would be decomposed, and the product will be a thin, brownish-black tar, resembling the product of the first distillation but slightly. When such crude oil is passed through the carburettor of an ordinary water gas set at a high red heat, the resultant tar is much thicker, and contains practically nothing which can be found in the original oil, while at the highest temperature available in oil gas apparatus the oil is almost completely destroyed, the product being practically pure carbon, or lampblack.

The quality of the crude also affects the tar, tars from light crude or distillate being lighter than those from heavy crudes, when run at the same heat.

The products from the distillation of coal also vary with the temperature used. Below a red heat the tar from fat coals closely resembles some petroleum products, being brownish in color, containing large proportions of phenols and nitrogen bases, little or no naphthalene, and very little pitch. The oils from this tar are lighter than water, while those from high temperature tars are much heavier. At the moderate red heat of an iron gas retort the tar is somewhat thicker, though still fairly limpid, is quite black, contains less of phenols and bases, and much more pitch. At the high red or low yellow heat the tar is still heavier and thicker, contains less bases and phenols, a large proportion of naphthalene and pitch, and considerable free carbon dust. At the highest heat to be had with clay retorts the tar is very thick and heavy, contains but little phenols, very much naphthalene and pitch, and large quantities of carbon dust.

The tars given by different coals at the same heat vary but little in quality, though the yield per ton varies considerably with the quality of the coal. The chief differences in the quality of tar are due to varying temperatures of distillation. The same may be said of tars from oil, and, indeed, two tars from one grade of coal or oil, run at widely different temperatures, will vary more from each other than two tars, one from coal, the other from oil, but run at the same heat. This, however, will apply only to tars from Pacific Coast oils, which, as is well known, differ radically from the oils of Eastern states.

To compare the qualities of coal tar with those of oil tar, it is necessary to compare them at a given distilling or gasifying temperature, and before doing this a word should be said as to the crude products commercially obtained from gas tars in general. Tar is refined, first,

by distillation in small iron stills, this being a simple fractionation. The products of this distillation are:

1. Crude Benzole—a volatile liquid, lighter than water, and used as a solvent. This material is the source of a great number of compounds used in the drug trade and in dye manufacture, but on the Pacific Coast is used in the crude state.

2. Heavy Oil, Dead Oil or Creosoting Oil—a liquid considerably heavier than water, and used in the crude state for creosoting timbers. From this oil may be taken:

Nitrogen Bases—Valueless.

Naphthalene—used as a disinfectant and in dye making, but principally valuable in the creosoting oil.

Phenols—Carbolic acid, cresylic acid, etc.

Neutral Oils—Pure hydrocarbons, heavier than water. Of no value except as the base of creosoting oil.

3. Anthracene Oil—A very heavy oil, containing anthracene, a solid substance which is much used in dye making. This oil is not distilled off in this country, but is left in the residue or pitch.

4. Pitch—A solid black material, similar to asphalt, and having about the same uses.

The following table shows quantity and quality of the various products of average samples of coal tar and oil tar, made at different heats:

	Below Red Heat		Low Red Heat		Red to Yellow Heat		Yellow to White Heat	
	Coal	Oil	Coal	Oil	Coal	Oil	Coal	Oil
Specific gravity of tar	0.98	1.02	1.09	1.06	1.19	1.22	1.25	Practically pure carbon—lampblack
Per cent. Benzole	5	24	6	4	2	2	2	
Quality of Benzole	Impure	Impure	Good	Good	Fair	Fair	Very Poor	
Per cent. Heavy Oil	35	41	39	54	28	21	16	
Per cent. Phenol in H. Oil	33	Trace	49	Trace	10	None	9	
Per cent Naphthalene "	None	Trace	None	10	42	59	68	
Per cent. Neutral Oils "	67	100	71	90	48	41	23	
Per cent. Pitch	60	35	55	42	70	77	82	
Per cent. Free Carbon in Tar	None	Trace	7	5	19	12	38	90-95
Number	924	2407	296	330	804	354	305	

It will be seen from this table that, aside from the practical absence of phenols in oil tar, the two tars at any given heat can hardly be distinguished. The phenols are a very essential constituent of creosoting oil, and are of considerable value in their pure state, so that their presence adds to the value of coal tar. There are minor differences which can hardly be tabulated, such as the greater drying power of oil tar, the somewhat greater flexibility of the pitch, etc., but in general it is safe to say that, for use in the crude state, or for the manufacture of benzole, naphthalene or pitch, no difference of commercial importance can be found between tars made at any one heat from bituminous coal or California petroleum.

It is along such lines of research, it is through the dissemination of knowledge such as that just given, it is by the compilation of information from every authentic source, and it is by giving wide and continuous publicity to such matters that the great industry of gas making and distribution is to be lifted from its slough of apathy, the apathy that has become as another name for gas engineering and which is responsible for its chief shortcomings. And to do all this by every means within its power constitutes the self-allotted task of THE JOURNAL.

IN DISCUSSION OF THE "QUESTION BOX" OF THE PACIFIC COAST GAS ASSOCIATION.

DURING the second day's session of the recent Twelfth Annual Meeting of the Pacific Coast Gas Association, the "Question Box" became the subject of considerable discussion of an interesting vein. Although these questions and the answers thereto have been published*, it is convenient to reproduce such of them as now come under consideration:

QUESTION: Who are the largest consumers of gas, the poor, the middle class, or the rich?

ANSWER—The rich are the best patrons of the company, considering total revenue received from both gas and electricity. The largest percentage of consumers are among the middle class.

MR. LOWE—Do I understand that to apply to companies supplying both gas and electricity?

THE SECRETARY—Yes. It was answered by a member of the Association who has both to deal with.

MR. KANEEN—My observation has been that, so far as a gas company alone is concerned, the most valuable consumers are found among the middle classes. I have made a study of the question, and I have found that the middle classes are the best consumers by thirty-four per cent on the basis of the total number of consumers and a twelve months' consumption.

MR. LOWE—Do you object to stating the name of the town?

MR. KANEEN—No. San Rafael.

MR. MARTIN—There is another point: the houses of the middle class do not cover as much ground as those of the rich and you have more consumers per mile of main.

MR. LOWE—I think that gas for fuel is introduced most easily into the homes of those who do their own cooking. I have had a great deal of experience in that line during the last twenty-six years, and I have found that the wealthy person cares little if the servant has to haul in coal and haul out ashes. The wealthy man looks more to the dollar and cent proposition, and if coal and wood are cheaper, he will use them in his home. Under these circumstances the development of the gas business in that class of homes lies wholly with the servant. When you have taught the servant the economical use of gas you will find a broader field among the wealthy classes. I remember one instance of a gas consumer whose bills for solid fuel would range from $10 to $15 a month who put a gas stove in his kitchen and whose bills for fuel gas ran from $30 to $40 a month. He said he was familiar with the fact that gas should cost less, but that he could not make his old colored servant whom he had had for years use it economically and therefore preferred to do away with it.

THE PRESIDENT—So far as lighting is concerned, the rich use little gas. Electricity is a luxury.

QUESTION: What has been the experience of the members with the Barrett Jack, manufactured by the Duff Manufacturing Company?

ANSWER—The Barrett Jack has become a part of our street equipment, whenever wrought-iron pipe is to be introduced either length ways or cross ways, much time is saved and a better job done. A saving in the sharpening of picks and renewals of shovels; it obviates the opening of long trenches and the filling of same. As we have forced 2½" pipe 190 feet, coming through within 3" of where pointed for, time one hour and a half, two men from the time of setting the Jack until pipe made its appearance at the far end. We have forced 4" pipe 56 feet under railroad (diagonally) where digging on trench-

*THE JOURNAL, Volume XIV, page 327 *et seq.*, August, 1904.

ing would not be allowed by railroad company, without evading legal questions.

Our latest is running a two-inch pipe 600 feet, digging 20' and forcing 40' alternately the whole distance, using the Jack as a macadam buster in the sections to be dug. The tool pushed along under the macadam raising it after the manner of a mole, leaving it ready for the shovel. No picks required.

Introducing services under cement sidewalks and meeting with brick or other foundations to be pierced, withdraw the forcing pipe and clean it, introduce it again, slip a smaller pipe saw toothed on the end, using it as a hollow drill and the forcing pipe as a guide, and proceed to drill.

Our experience is to use nothing smaller than a 2" pipe to force with where a straight hole is desired, a 2½" or 3" is still better in tough jumbo or adobe ground, roots, fence posts, brickbats, miscellaneous dumps and sometimes a tree we have surprised ourselves by passing through.

In obstinate cases we hitch a rope on the end of a five-foot lever, put three or more men on either side of the lever, and so far have never been stalled.

We are now engaged on a Siamese, or double, forcing arrangement giving a pressure of thirty tons and needing no extension pieces, laying the pipe as it goes.

MR. KEYES—I have had some adverse experience with the jack. I bought one for Stockton and one for Sacramento, and have found in a number of cases where we were putting in 1¼ inch or 1 inch service pipes that the moment the point struck a root or a brick there was a tendency to divert the point, and we would find it about four feet deeper at the inner end than where we started, and would have to take it out. Where the soil is soft and there are no impediments in the way it is a great saver of time and labor.

THE PRESIDENT—Did you use a point?

MR. KEYES—Simply a plug in the end of the pipe.

THE PRESIDENT—You should have used a point. Did it have any effect on the coating of the pipe?

MR. KEYES—We paint all our pipe with red lead and oil, and where we have pulled the pipe out again there was considerable of the surface where the paint had been scraped off.

MR. LOWE—I am inclined to think that if you use a jack to force pipe, or if you drive it by any other means, the best thing to use as a point is red lead; but under those circumstances the coating should be quite old. I think that gas companies occasionally run across conditions under which they are compelled to force pipe, and for such use they should have on hand sections of pipe which have been painted for fully a year. The action of red lead paint is a chemical one in that it forms a cement on the pipe, but before it is entirely hard and tenacious it must be old. It will then stand a great deal of abrasion, but of course if the pipe comes into contact with hard surfaces, and the friction is very great, any coating must be abraded.

MR. JONES—I have been told that the best point is a small piece of pipe, allowing the earth to form its own point. That, I believe will obviate some of the trouble had in the pipe turning aside when it meets small obstructions.

MR. PEDERSEN—I was in Ventura some time ago and saw them using one of the jacks there. They had a small attachment on the driving lever which gave a circular motion to the pipe as it was forced through, and they seemed to have no difficulty about the swerving of the pipe. I saw them drive 150 feet, going under a railroad track and out on the other side, and they were not half an inch out of the way. I thought it possible that this might be due to the circular motion of the pipe.

MR. GUNDER—I had some experience in the use of the pipe jack in laying 3-inch pipe for the Sunset Telephone Company in San Jose. The pipe did not vary an inch from the line. By using a cap we made the holes so large that the friction was cut down to a minimum.

MR. LLOYD—I tried a point at first and had the same trouble that Mr. Keyes did. Then I had a round chisel made that set over the socket and tried to force the pipe, but whenever it struck a rock it either went down or up. I tried it on 2-inch pipe and the pipe doubled up before we could force it. We had to abandon the jack and use pick and shovel.

MR. LOWE—The value of the jack depends entirely upon local conditions.

MR. PARKER—We have used the jack in almost every condition of clay and gravel and succeeded admirably.

QUESTION: To what if any are the objections to wrought-iron purifiers instead of cast-iron ones?

ANSWER—Cast iron was employed before steel construction had reached its present state of excellence. There can be no objection to the use of wrought iron or steel, if strains are properly calculated and provided against by reinforcement, and the metal is properly protected by paint.

MR. HILL—In this connection I would like to ask what kind of paint to use on a purifier where the water seal comes.

MR. JONES—I do not like to repeat this too many times. I think I began to talk about it in New England twenty years ago. I had similar trouble in New England and overcame it by using beef tallow and white lead. Place the tallow in an ordinary can and immerse the can in a pot of boiling water until the tallow is thoroughly melted. Mix the lead with the melted tallow and heat the pot containing the tallow and lead in this hot water while it is being used, and apply the melted substance to the side of the purifier covers while the material is still hot, never heat it, but mix it in quantities as needed. It won't rub off, and protects the iron entirely against rust or the action of moisture. The moisture in the water seal never penetrates. The idea occurred to me by reading an account in the *Scientific American* fully twenty-five years ago of a lot of sugar machinery shipped to Havana. The ship was sunk. A wrecking company took up the machinery after it had been in the water a long time, and it was found to be intact. It had been coated with tallow and white lead before it left New York.

QUESTION: Has any member used in the manufacture of crude oil water gas oils of different gravity? If so, have they kept strict account of the relative value of each for gas making; *i. e.*, the number of cubic feet of gas made per barrel from the different grades or gravity of oil? What are the results shown?

ANSWER—Yes, all grades have been used and the lower grades have given somewhat better results than the higher. Strict records have been kept, but are not at hand.

MR. LOWE—I replied to that question. A gallon of fourteen gravity oil weighs roughly, eight pounds. A gallon of Coalinga oil, we will assume, weighs seven pounds. We buy our oil by measure and use it by weight, and the oil that will give you the greatest number of pounds per gallon is naturally the best oil to use. Oil of less than fourteen gravity is difficult to handle. The lowest gravity oil I have handled is eleven and one-half. Generally speaking, fourteen gravity oil can be handled with reasonable ease, and under these circumstances it is to be preferred.

QUESTION: How many gallons of water per hour should pass through a crude oil water gas machine making 5000 feet of gas per hour?

ANSWER—The quantity of water necessary for cooling and cleansing the gas depends in a great measure on the type and efficiency of the apparatus used for condensing and scrubbing. In one of the larger crude oil water gas plants, it has been found that 64 gallons of water were sufficient to condense and scrub the gas. This amount of water reduced the temperature of the gas to 60° F., and removed all solid suspended matter. In practice it has been found that 80

gallons of water per thousand cubic feet will cool and cleanse the gas satisfactorily. The amount of water necessary to produce 1000 cubic feet of crude oil water gas, including all water fed to the boiler for the making of steam, for gas making, and the operation of auxiliaries including boiler feed pump, oil pumps, pumps for handling, condensing and scrubbing water, exhauster and hoisting engines for cleaning out lampblack separator, but not including any water for condensing and scrubbing, amounts to 18.1 gallons, or 150.77 lbs. per thousand.

Weight of water used in this calculation American gallon of 231 cubic inches, weighing 8.3356 lbs.

MR. LOWE—In general, where water is scarce, as it is in some localities, or where you must buy your water, water used in gas washing and scrubbing can be re-used by having settling reservoirs. It greatly lessens the ultimate expenditure for water.

MR. HILL—I would like to ask what effect the temperature of the water has. Is it essential that the water be cooled, or would it make any difference if it happened to be warm?

MR. LOWE—The colder, the better the result. In your washer you might use warm water, but it is essential to send your gas from your apparatus cold.

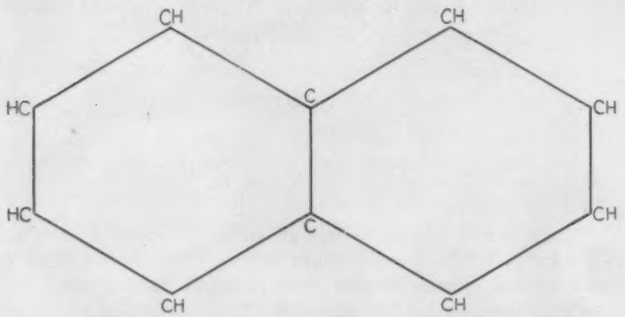
MR. HILL—Would you say that to use warm water would be of no use?

MR. LOWE—It would be of less value than colder water.

MR. JONES—If water is a very scarce article the hot water might be used for scrubbing and the gas afterwards treated with a smaller quantity of cooler water.

QUESTION: What is naphthaline?

ANSWER—Naphthaline C 10 H 8 is an aromatic hydrocarbon which was discovered December 15, 1819, by A. Garden, and formed in the distillation of coal tar. Afterward J. Kidd obtained the same substance by passing the vapors of coal tar through a red-hot tube, and gave it the name of "Naphthaline." (Phil, Trans. 1821, 209.) Its correct composition was first determined by Faraday. (Phil. Trans. 1826, II, 140.) It was first assumed that naphthaline existed as such in coal, but this idea was shown to be not accurate, but that naphthaline was a product formed by distillation. Erlenmeyer proposed the following formula, which consists of two aromatic nuclei which have two carbon atoms in common:



Naphthaline is sometimes formed by the condensation of hydrocarbons of the acetylene series. Berthelot found that by heating acetylene to a temperature at which glass softens, that a considerable quantity of benzine and naphthaline is produced. Naphthaline crystalizes in plates, has a characteristic unpleasant odor (well known to gas men), melts at 79.2° C. and boils at 218° C. Its specific gravity compared with water at 4° C is 1.145; at 80°, 0.9777.

MR. JONES—A question of that kind ought to be answered by the books in our library, and I want to urge the members of the Association to write to the librarian for books on chemistry or physics which bear upon subjects they have in mind. Their requests for books will be promptly attended to.

QUESTION: When making gas into an unweighed holder—exhausting from same (with varying steam) into a weighted holder—and supplying gas to the town, all at the same time, how can the amount of make be accurately figured, there being a difference in the atmospheric temperature of from 20° to 40° during twenty-four hours?

ANSWER—The above question represents emergency conditions, which should be remedied by the introduction of a station meter between the purifiers and the storage holder.

A MEMBER—Do I understand the answer to be that the gas meter would register correctly, regardless of temperature?

MR. JONES—Yes. It would register correctly, regardless of temperature. It will register correctly the volume of air, which weighs over twice as much as crude oil water gas. Still it may be used for registering correctly the number of cubic feet of air and the corrections for temperature and barometric conditions must be made by you in order to get the correct result.

A MEMBER—If a meter were placed where the temperature is 95 per cent, and then the same meter were placed where the temperature is 75 per cent, would not that alter the percentage of the meter?

MR. JONES—I believe the gas does not remain long enough in the meter to affect the volume in passing through it. And the remedy at hand is to find a place for your meter where the temperature is more nearly the temperature of the gas as you care to sell it. Another thing, our old friend the "Gas House Devil" gets in when you put the meter where it is either hot or cold.

A MEMBER—It is true that the meter should be set in a cool place, but there are cases where you can not set the meter where the temperature of the gas and the temperature of the meter will be the same. We take the temperature of the water and the air to get the correct test of the meter. I should think the same would apply in taking the temperature of the gas and the temperature of the place where the gas had to pass through the meter.

MR. JONES—That is important in proving a meter because we have inherited our ideas in regard to proving meters from our English friends. Of course we all understand that the volume of gas stored in holders is affected by temperature. But the ground temperature at the average depth of gas pipes is below the atmospheric temperature in summer time in all of our towns, so that, if the meter is placed in an ordinarily cool place, the difference between that and the temperature of the ground would even up, so that you would not be selling gas in an attenuated form, and, again, you would not be cheating yourself by shrinking the gas by passing it through a cold meter in the winter time. It passes through so rapidly that there is little effect.

MR. BRITTON—We have had experiences which seem rather to upset the theory. Sometimes there is an installation where the main meter is placed underneath the house in the basement, where it is reasonably cool, and from the house pipe would be taken a number of what we call "supplemental meters" supplying stoves placed in the kitchen, the meters being placed near the stoves and subject to a great increase in temperature. We have had very great differences,—probably as high as 50 per cent—between the total registration of the meters supplemental to the main meter and the registration of the main meter that fed them all. This difference in registration I attribute entirely to the drying up of the diaphragms of the meters, due to the heat, thereby increasing the registration. These supplemental meters when taken out and tested oftentimes ran 50 per cent fast.

MR. DOHERTY—I do not think I ever attended a gas convention or talked to gas men when the question of temperature and pressure has not come up regarding their effect on the volume of the gas. I would simply suggest that one of the primary studies every gas man should take is a study of the law of Charles (or of Lussac) and the law of Boyle. The law of Charles is that the volume of gas of given pressure will vary directly as the absolute temperature. The law of Boyle is that the volume of gas will vary inversely as the pressure, or the pressure times the volume will always equal a constant. If you have one cubic foot of gas under a pressure of 14.7 and you increase the pressure to

29.4 you will have half the volume you had before. If the gas man would familiarize himself with these two laws he would save a lot of puzzling problems that come up. Unless he has the laws at his finger tips he will often be puzzled.

MR. KEYES—The experience of Mr. Britton has been similar to mine. I have a number of apartment houses where the gas all goes through one meter and is supplemented by meters in the kitchen. In one case we have seventeen meters set in the kitchen, the gas going through one meter first, and I find considerably more money coming from these meters (they are of the pre-payment type) than the large meter registers. I accounted for it from the fact that, as Mr. Britton says, the diaphragms must contract from the heat and therefore give a larger registration. I could not account for it in any other way.

THE PRESIDENT—May not the explanation be that your consumers placed a quarter in the slot the day the meters were read?

MR. KEYES—In reading the meter we read not only the money but also the amount registered on the meter.

MR. DOHERTY—There is one answer in there that Mr. Britton read in regard to the calorific value of the heavier hydrocarbons which it seems to me should not go unchallenged.

MR. JONES—I answered that question. Have you ever had any experience with the calorimetrical testing of acetylene gas? Acetylene gas today is very easily made from calcium carbide. It is used in automobile lamps and for a great many other purposes. It has a calorimetrical value, theoretically, of 1,555 British thermal units to the cubic foot. In actual laboratory practice with a Junker calorimeter it is impossible to develop as many heat units from acetylene gas as it contains *acetylene which has 1,682 units.* I believe you can get about 1,200 units out of acetylene gas, showing that the calorimeter is a fallible instrument. Its principle is the burning of gas through a Bunsen burner adapted to the use of all gases. The answer to the question did not apply to the Bomb calorimeter where we get all the heating value of the substance experimentally. It referred to the use of gas in Bunsen burners, gas stoves and heating devices, or in any of our other forms of calorimeters, such as the Junker. I received some data recently in connection with the use of gas in gas engines in which it said that gas diluted with either products of combustion or air would develop a horsepower with 9,700 British thermal units, but that if acetylene gas is used with a proper proportion of air it requires 16,000 British thermal units to develop a Brake horsepower.

MR. DOHERTY—I have measured acetylene gas with a calorimeter similar to the Junker, and I have determined the value of acetylene gas, and, as I remember it, it shows a calorimetric value to exceed the elements, that is, showing that it was exothermic in decomposition. Now I see no reason why the Junker calorimeter, barring a few chances for slight errors, should not give us the true measure of the total calorific value of our gas. I believe it is the best in the market, and I can not see how we can get anything but the total calorific value of the gas, unless some products escape without being burned, and I can hardly conceive of any unburned products passing away from the Bunsens, especially if the gas used is a gas like acetylene or any of the gases having a low ignition temperature and a great affinity for oxygen. Now Mr. Jones refers to the effect of acetylene gas in a gas engine. I think that is due entirely to another reason. Take a gas and dilute it with some inert gas, and you can run the compression up much higher, perhaps, than without it. Take acetylene gas and you have a gas with a low ignition temperature, and before you have compressed it to the extent you would compress a gas free from hydrocarbons you will reach the temperature of ignition. I think the reason for the considerably greater consumption of acetylene gas is that you can not run your ignition up to an economical point.

MR. JONES—The richer hydrocarbons in our gas which develop light are very unstable, and as you make these hydrocarbons heavier they become less easily oxydizable. They do not burn so readily. And in the Junker calorimeter, if you are using a gas like acetylene, where the air supply is not exactly the correct amount, proper oxydation of the gas does not take place, and the result is a deposition of solid carbon somewhere. I believe that is true in a gas engine. I believe that in internal combustion engines we would not get the true value of either benzine vapor or naphthalene.

HOW TO SAFELY EXPEL AIR FROM GAS APPARATUS, MAINS AND HOLDERS.*

BY E. C. JONES.

IT often becomes the duty of those in charge of gas works to expel the air from new pieces of apparates, from gas holders and from new installations of street mains. This, in the vernacular of the gas man, is called "purging," and the writer has been unable to find any safe rule to accomplish the expulsion of the air, laid down in any books on the subject of gas manufacture.

It is customary in the starting of gas works to blow out the air through an opening at a point farthest from where the gas is admitted, and the air is allowed to escape until it has a strong odor of gas, when it is taken for granted that the air has been displaced by gas. Sometimes a test is made by lighting the gas through a burner containing a piece of wire gauze, and the fact that the explosive limits of mixtures of gas and air are within so narrow a range has prevented many serious accidents. It is hard to say whether the lighting of gas at such times is due to bravery or ignorance, but if it is due to the former it usually menaces the property of others than the man with the match.

The use of wire gauze for preventing the passage of flame is dependent upon so many conditions that it may be safely said, it is never without danger, and although this safeguard is based on the well known Davy miners' safety lamp, no dependence should be placed upon it without absolute knowledge of the composition of the gaseous mixture and air, its ignition temperature, flame temperature, the degree of fineness of the wire gauze and its strength.

It will be readily seen that it is next to impossible to determine all of these conditions, and it is well known that slight changes in the conditions will cause the same mixture of gas and air, which may theoretically be safely lighted through a No. 16 gauze, to explode through a No. 100 gauze.

The writer has successfully used a simple and positive means of determining the amount when all of the air is expelled from any piece of apparatus by means of samples of the gaseous mixture taken out of the apparatus as the air is being expelled and tested at a safe distance.

All that is necessary to perform this experiment is an ordinary wooden bucket filled with soap suds. The soap suds may be made by first filling the bucket with hot water and whittling into it a bar of common soap. In connection with this bucket of common soap suds, a small rubber gas bag, such as is used for stopping six-inch or eight-inch mains, is used for collecting the samples of gas.

Suppose it is desired to expel the air from a long stretch of large gas mains, a good sized pipe should be brought to a point five or six feet above the surface of the ground. At the top of this pipe it should have a funnel covered with fine wire gauze, carefully soldered around the edge. The size of the funnel is dependent upon the fineness of the wire gauze, and the enlargement is for the purpose of not contracting the area of the blow-off pipe. In this upright pipe there should be a damper, operated by an iron handle, similar to the damper used in stove pipes. This damper may be made of stiff cardboard. Below the damper there should be an ordinary pet cock. These being provided, the gas is turned into the main and the damper in the blow-off pipe is opened, allowing the air to pass out through the wire gauze.

When it is desired to make a test, the damper is closed and the rubber attached to the pet cock, thus obtaining a sample of the mixture obtained in the main. This sample is then taken to some

**The Purifier*, October, 1904.

distance from the point where the air is being blown out, and the rubber tubing attached to the rubber bag is placed in the bucket of soap suds. By squeezing the rubber bag the air, or gas and air, is forced through the soap suds, forming large bubbles on the surface. Light a match and ignite the bubbles, taking care that flame does not reach the gas in the rubber bag.

These experiments are interesting as they proceed. First, the air in the bubbles will extinguish the match; then, as the gas becomes mixed with the air in the pipe, the bubbles will explode with a loud report. After the danger point has been passed, the gas in the bubbles will burn, and finally, when all the air has been expelled, the gas in the bubbles will slowly burn with a brilliant flame; so that, besides knowing that all the air has been expelled, the quality of the gas in the main may be determined according to the judgment of the experimenter.

After the air has been expelled, it is simply necessary to remove the blow-off pipe and plug the opening. This is accomplished after closing the valve which originally admitted the gas into the new main.

The application of this method of expelling air from new gas holders is made extremely simple, safe and quick by making a blow-off pipe of tin or galvanized iron with a flange of the same material. This blow-off pipe is made as large as is permitted to pass through the manhole in the crown of the holder, and the pipe should extend down to within a few inches of the surface of the water in the holder tank, and the pipe may be suspended by a flange of the same material soldered on at a point where it will rests on the crown of the holder and hold the pipe in place in the manhole. This pipe should extend upwards to a point above the head of a man and should be flared out into a funnel, on which is carefully soldered a sheet of fine wire gauze. A butterfly valve, made of paste or mill board, as previously described, is provided, and a pet cock is placed below the valve. When the gas is turned into the holder, it rises to the crown and the air is forced downward and up through the blow-off pipe from a point near the surface of the water. It is surprising how quickly the air may be expelled without becoming mixed with gas. The writer has made tests within ten minutes of each other in blowing out the air from a 2,000,000-foot gas holder, where the first test showed no trace of gas, the second burned with a faint yellow flame, and the third burned brightly, showing no presence of air. This work was done so quickly and well that at no time was it possible to obtain a sample of explosive mixture of gas and air.

In starting up new pieces of apparatus in old gas works it will be found safe and convenient to blow out the apparatus backward with gas already made, rather than to depend upon new generating sets to displace the gas in the condensers, scrubbers and purifiers. Many explosions have been avoided in this way.

Following is a table showing the air required for the complete combustion of various gases:

Heavy hydro-carbons: $C_2H_4 + 3O_2 = 2CO_2 + 2H_2O$.
One volume requires 14.28 volumes air or 3 volumes oxygen.

Carbonic oxide: $2CO_2 + O_2 = 2CO_2$.
One volume requires 2.38 volumes air or ½ volumes oxygen.

Hydrogen: $2H_2 + O_2 = {}_2H_2O$.
One volume requires 2.38 volumes air or ½ volumes oxygen.

Marsh gas (Methane): $CH_4 + 2O_2 = CO_2 + 2H_2O$.
One volume requires 9.52 volumes of air or 2 volumes of oxygen.

The danger point with coal gas begins at 7 per cent. of gas mixed with 93 per cent. of air, and ceases when the mixture contains 23 per cent. of gas and 77 per cent. of air. The range of explosibility in water gas is between 7½ per cent. of gas and 92½ per cent. of air and 26 per cent. of gas and 74 per cent. of air. Below the minimum amount of gas the mixture will not burn, and above the maximum amount of gas the mixture will not explode, but will burn freely.

Following are ignition temperatures, according to Messieurs Mallard and Le Chatelier: Hydrogen, with necessary portion of air, ignites at 1020 degrees Fahrenheit, and different mixtures of hydrogen and oxygen, and hydrogen and air ignite at various points between 985 degrees and 1100 degrees Fahrenheit. All the different mixtures of carbonic oxide and oxygen or air ignite between 1110 degrees and 1220 degrees Fahrenheit.

The writer hopes that the above simple way of finding out when all the air is expelled from gas apparatus with perfect safety will afford the comfort and piece of mind which comes with positive knowledge (and can never be obtained by guessing), will save your company gas, give assurance of the safety of your company's property, and avoid your own worry and nerve wear.

INDUSTRIAL

THE PELTON WATER WHEEL AT THE ST. LOUIS EXPOSITION.

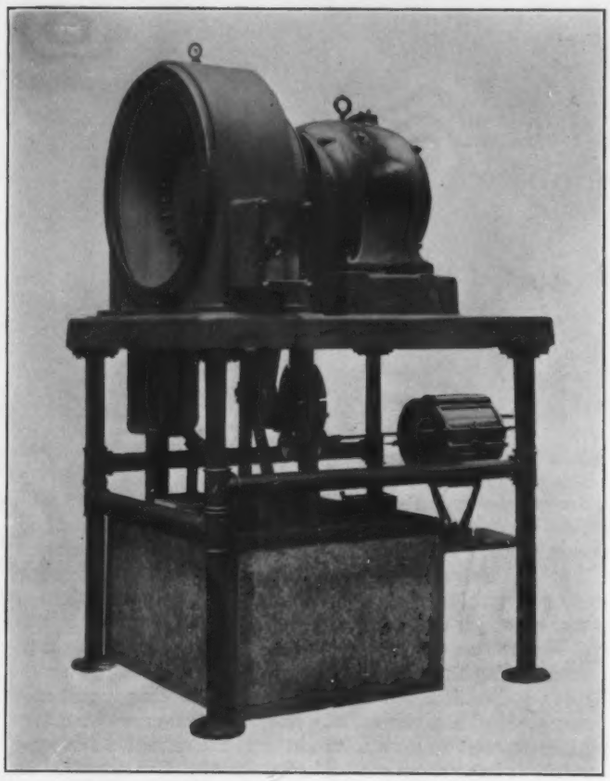
THE exhibit of the Pelton Water Wheel Company at the Louisiana Purchase Exposition, though of small area, is very comprehensive aud instructive in that it aims to demonstrate graphically several hydraulic theories which have heretofore been deduced only from calculation. It goes even further by disproving other generally accepted theories which are the result of mistaken observation.

As is doubtless known, the impulse wheel, of which the Pelton is the pioneer, consists essentially of a cast iron or steel center, to the periphery of which are affixed cups or "buckets," as they are technically called. Water under pressure is allowed to impinge on these buckets, causing the wheel to revolve with the shaft on which it is mounted.

The efficiency of a wheel of the Pelton type is to a very large extent due to the shape of the bucket, and as efficiency is a most important factor in the development of every power proposition, it is the bucket and the action of the water upon it which engage the most attention.

One of the fundamental principles of hydraulics, as applied to impulse wheels, is that the water must "enter without shock and leave without velocity." The nearer the approach to this condition the higher will be the resultant efficiency. Early experiments with the Pelton bucket demonstrated the fact that, in order to obtain a complete reversal of the stream, with practical absence

PHOTOGRAPH A. SKOBISCOPIC VIEW OF PELTON WHEEL WHEN RUNNING AT HIGH EFFICIENCY, SHOWING THE DISCHARGE FROM THE SIDES OF THE BUCKETS PARALLEL WITH THE ENTERING JET. THIS ALSO SHOWS CLEARLY THAT THE FRONT OF THE PELTON BUCKET ENTERS THE STREAM WITHOUT SHOCK OR DISTURBANCE OF ANY KIND, AND THAT ALL THE ENERGY IS REMOVED FROM THE WATER



PHOTOGRAPH B. GENERAL VIEW OF SKOBISCOPIC APPARATUS

of velocity, it was essential that the bucket be divided into two parts by a wedge or splitter on which the stream might strike on entering The stream of water being thus divided, the two halves follow the curvature of the bucket and discharge backward and downward at a slight angle, so as to avoid interference with the succeeding bucket. To obtain this result it is necessary that the bucket curves be laid on lines of the least resistance and that the splitter bear a certain relation to the bucket sides.

In designing a water wheel bucket and attempting to carry out a particular theory it is, of course, necessary to lay out the bucket shape mathematically, and then, following well known hydraulic laws in regard to the flow of water on surfaces, note the curves and paths which the stream should follow. This plan—the only one heretofore known—has been productive of some excellent results; but the fallacy lies in the fact that most of the hydraulic laws above referred to were deduced from observations of water action against stationary surfaces; or, if moving, the path of the water was so obscured by spray and the moving wheel that the observations have in some cases led to mistaken theories, which are now disproved in actual practice.

The problem is, then, to observe the action of water on moving surfaces as though they were standing still (see photo "*A*"). This is accomplished by applying the "skobiscopic" principle to the observation of a water wheel in actual operation, which principle may be described as being the reverse of the kinetoscope, in that moving objects are seen as stationary, instead of apparent motion being given to stationary objects. The principle is that if a moving object be illuminated at fixed intervals by rays of light admitted at the moment the object passes a desired position, each portion of the object will be observed as though it were stationary. Thus is secured a clear view of what occurs in the buckets of a water wheel while it is operating under normal conditions (see photo "*B*").

As an exponent of this principle is exhibited the apparatus, consisting of a Pelton water wheel twenty inches in diameter, mounted on the overhanging shaft of a General Electric generator. The water impinges on the wheel through a needle nozzle, the pressure being supplied by a centrifugal pump. The luminant is a General Electric searchlight projector with automatic focal point control, which is located beneath the apparatus, and which, by a system of mirrors, throws its rays into the wheel housing through the glass bottom. In its normal position the light is thrown direct on the wheel, under which condition the wheel may be seen revolving and the water discharging from the buckets in apparent confusion. Interposed between the searchlight and the wheel is a sheet iron disk with radial slots, which disk is revolved by means of gearing at a speed proportional to that of the wheel. When the searchlight is automatically brought into its upper position the light is thrown on the wheel *through* these revolving slots, and thus the wheel is illuminated at fixed intervals, as explained above, and one sees the wheel apparently standing still and can observe the action of the water and trace the path of the jet from its entering the bucket to its reversal and clearance of the succeeding bucket without interference.

From a careful observation of this exhibit in operation will be observed to exist the following conditions, which are the main essentials to the attainment of a high bucket efficiency in an impulse water wheel:

First—That the front lip ot the bucket in entering the stream of water produces absolutely no disturbance.

Second—That the water velocity is taken up on the surface of the bucket on a line vertically under the shaft center, and when the bucket surface is in the most advantageous position.

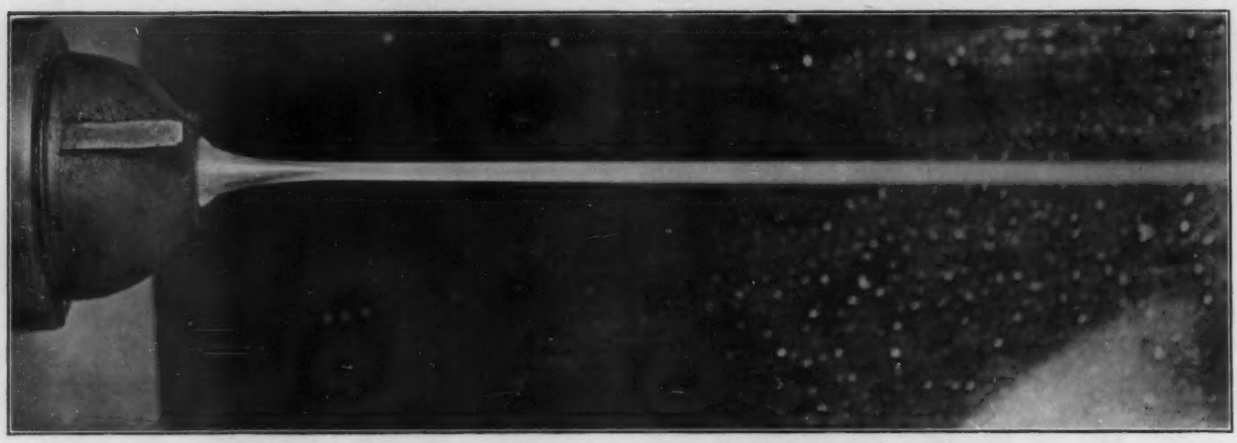
Third—That the water discharges from the sides of the buckets without interference with the succeeding buckets or the wheel center, and with a minimum velocity of discharge.

Fourth—That the water is *not* carried around with the wheel, the discharge occurring as soon as the water has transferred its energy to the rotating wheel.

Fifth. That no twist or disturbance occurs in the water jet; hence the development of the greatest possible power from the moving water (see photo "*C*").

The bucket curvatures for obtaining these resnlts, as here illustrated, have resulted in securing from operating wheels bucket efficiencies in excess of 90 per cent., exclusive of journal friction and windage losses. In the actual construction of Pelton water

PHOTOGRAPH C. TANGENTIAL WATER WHEEL FITTED WITH PELTON BUCKETS, SHOWING THE DISCHARGE AT ALMOST ZERO VELOCITY, AND ALSO THAT THE SHAPE OF THE JET IS MAINTAINED UNTIL IMPACT IN THE CENTER OF THE BUCKET WHERE THE ENTIRE ENERGY IS REMOVED FROM THE WATER BY THE BUCKET, RESULTING IN MAXIMUM EFFICIENCY



PHOTOGRAPH D. A STREAM OF WATER FROM A PELTON NEEDLE NOZZLE

wheels for high duty, such as power transmission plants, the buckets are always specially designed to secure best efficiency under the actual conditions of operation.

The apparatus presented is for exhibition purposes only, and to obtain practical results the Pelton Water Wheel Company has a permanent installation on a large scale in its San Francisco laboratory, where exhaustive experiments are conducted. Not relying on visual observations alone, resort is had to photography as a permanent aid in studying the action of the water on the buckets. In this laboratory also are instrument of precision for determining the relative efficiencies of different bucket shapes; and to such an extent is the investigation carried that it may be said that there are practically no "standard" buckets used in the construction of Pelton wheels, a new design being adapted to the head, water quantity and power requirements of each installation, thereby insuring the highest possible efficiency.

Regulation of any water wheel is necessarily at the expense of efficiency. In most cases it is accomplished by throttling the water by means of a gate, which materially reduces the working pressure. The Pelton needle nozzle (see photo "*D*") is a device which accomplishes the required result with the least loss in pressure and velocity and is consequently highly efficient. The needle nozzle consists of a conical shaped tip, in which is inserted a concentric tapered plug or needle, generally similar in shape to a "plumb-bob." A change of position of this plug causes a corresponding change of discharge area in the nozzle; the amount of water used is thus varied, and the power of the wheel influenced proportionately.

The peculiar curves of the needle and tip admit of the water changing its velocity gradually and uniformly, and the stream diameter may be varied from about one-tenth to full area without changing its circular form or losing its density. The combination needle and deflecting nozzle, embracing both features in one nozzle, is particularly effective in its results when varying loads are met with at certain periods of the day's run.

THE CHURCHER ALTERNATING RECTIFIER.

MUCH hard work must be done, difficulties overcome, methods of manufacture and sale perfected before any real success is achieved. Such has been the case with the alternating current rectifier, about which more or less has been written in the last few years. It is not a newly discovered fact that aluminum and some other metals have the faculty of developing upon their surfaces an insulating film when in contact with certain solutions and while electrically positive to another electrode in the same solution, but it has remained in an unperfected state.

The Churcher Alternating Current Rectifier is a decided departure from anything before constructed, and is now in marketable and practical shape. The best that has been accomplished heretofore was a very inefficient and crude device. A single cell with a pair of suitable elements will rectify part of the cycle of an alternating current, but this is not a true uni-directional current. It is still an alternating current in character with one alternation of greater amplitude than the other and giving an efficiency of perhaps 20 per cent when charging a storage battery.

This poor result is partially caused by the return or leakage current passing through the rectifier and through the battery in the wrong direction, hence discharging it. To charge a storage battery under this condition, it is evident that an excessive charging current must be used to overbalance the excessive discharge that takes place during one-half of the cycle. For example: In figures that are approximately correct, to charge a battery of cells aggregating 50 volts a potential of about 60 volts is ordinarily required. Supposing, for illustration, that this potential will pass 10 amperes through the cells on direct current circuit. In order

to charge at this rate from an alternating current with a single old-type rectifier it will be necessary to raise the charging potential sufficiently, say to 75 volts, to force 50 amperes through the cells, an excessive charge. This is because of the fact that the potential of the return wave of the alternation will be added to that of the battery and produce a serious leak through the insulating film on the aluminum electrode. The average discharge potential would be 50 plus 75 or 125 volts. Average, because at the peak of the alternation the actual potential would reach about 150 volts against the film, which is approximately its break-down point. This high return potential, as it may be termed, will cause a discharge of about 40 amperes, an excessive discharge rate. This leaves a net charging current of 10 amperes. It is pre-supposed that a battery requiring 10 amperes would have capacity of about 100 ampere hours, and hence it will be seen that in order to charge at 10 amperes from the old type of recti-

fier it was necessary to charge at 50 and discharge at 40 amperes, leaving the required margin for charging. At this rate the rectifier would be rapidly destroyed, and the best storage battery would be served likewise. A rectifier of that type is not worthy of further consideration, as it is of no more real value for other purposes than for charging batteries.

The next step was the combination of four rectifying cells, known as the Graetz method of connection. This combination was somewhat better, in that it rectified both waves of the cycle, and hence gave a true uni-directional current. The efficiency was necessarily low because of the fact that the resistance in the path of the useful current was double, and leakage was also double that of a single rectifier. The old type of single cell being inefficient to start with, the combination of four was nearly four times as bad, to say nothing of the wear and tear on four sets of electrodes and four solutions. The only gain was a really uni-directional current produced, so that in charging a storage battery all of the energy passing through it was available for discharge, barring, of course, inherent losses peculiar to storage batteries.

The next step was the perfection of the Churcher Rectifier. This device rectifies both waves of any alternating current and requires but one jar, one solution and one set of electrodes to do so. In this way the internal resistance is reduced to a very low point, in fact it is only limited by mechanical necessities to prevent short circuits. This loss is almost negligible. The principal loss that does take place is the leakage current. This current does not pass through the apparatus operated by rectified current, but is expended in heating the solution. This loss is largely dependent upon the electrode potential at the film, the purity of the aluminum and solution and its temperature. Where continuous service is required of the rectifier, it is therefore imperative to prevent this initial rise in temperature by the use of water cooling pipes or radiation of some sort.

This form of rectifier requires the use of a transformer with a secondary of twice the direct current voltage required, plus the resistance loss. This secondary coil is tapped in the center, and by virtue of the action of the rectifier this tap remains positive at all times to one or the other extreme terminal. The active electrodes are attached to each of the extreme secondary terminals, the number depending upon the phase of the alternating supply. Owing to the peculiar properties of the films on these electrodes, no appreciable current passes from either to the other. Electrodes of inactive material, such as platinum, carbon, etc., would short circuit the transformer. Between these active electrodes, but insulated from them, is placed an inactive electrode, preferably platinum. Connected between this electrode as one terminal and the center tap of the transformer as the other, is connected the battery to be charged, direct current motor or other apparatus to be operated. In operation the current passes from the center tap of the transformer to the motor, from the motor to the inactive electrode in the rectifier solution, to one or the other active electrodes, depending on which is at that instant negative to the center of the transformer. Inside the rectifier the current, therefore, passes from the inactive electrode first to one, then to the other active electrode, as the alternations of the cycle take place, the center of the transformer remaining positive at all times. It will be understood from this that one side of the transformer is active while the other is inactive, and then reversed during the next alternation.

The regulation of direct current is best attained by placing an adjustable inductance between the transformer terminals and the active electrodes of the rectifier. This regulation can also be very efficiently attained by an inductance in the main alternating supply or by varying the number of turns of wire in the primary of the transformer. Either form of regulation is, of course, much more efficient than placing resistance in series with storage batteries when charging from 110-volt direct current mains. It is also a well known fact that a pulsating uni-directional current is especially desirable for charging storage batteries. Just why it is so, is not very well understood, but the fact remains.

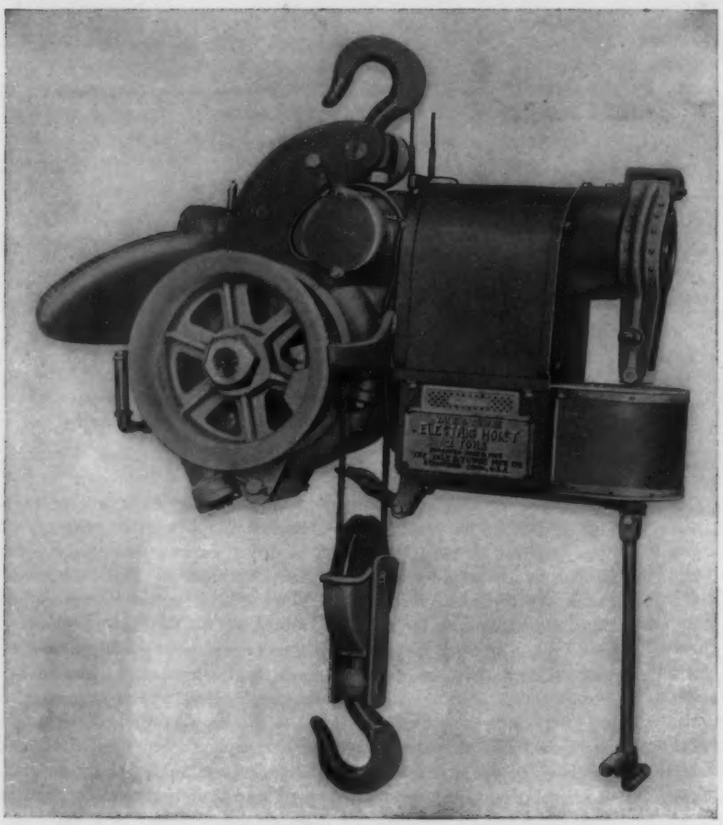
The practical limit of voltage of one cell of the Churcher Rectifier is about 50 volts direct current at full ampere load, or a difference of potential across the active electrodes of about 130 volts. Somewhat higher voltage may be obtained under favorable condition, but the efficiency is generally much lower because of the increased leakage from one transformer terminal to the other. Through the use of two cells and two secondaries in the one transformer twice the voltage can be obtained; three cells with three secondaries in the one transformer will give three times the voltage, etc.

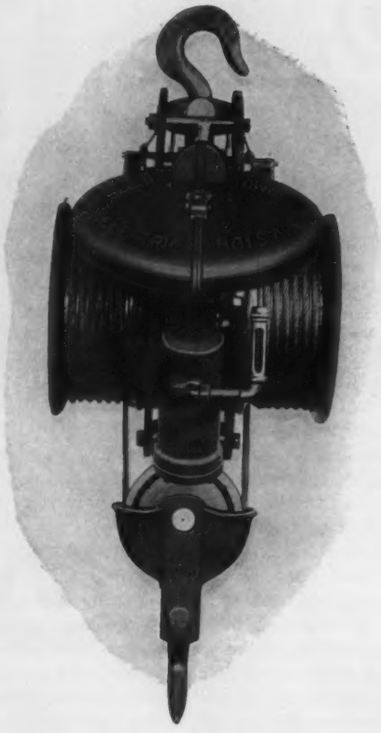
Thus it is evident that the Churcher system of rectifiers will deliver any potential of direct current from any alternating current. This statement may seem very broad, but it is perfectly true. Potential, phase, cycles, direct current, are all matters of detail, readily worked out by anyone familiar with the system.

RUSSIA'S ONLY BUILDING AT THE FAIR.

RUSSIA'S only building in the Louisiana Purchase Exposition, the center of much interest in the Palace of Transportation, excites only regret that the withdrawal of the Czar's government from formal participation in the fair has deprived it of larger and more comprehensive displays of the same attractive type. The pavilion in the Palace of Transportation, which was erected by the Westinghouse Company, Limited, of St. Petersburg, as a feature of the Westinghouse brake exhibits, is representative in every feature of Russian art and workmanship, and is recognized as the general Russian rendezvous at St. Louis. In the Palace of Machinery the same company, which has made every effort to insure a characteristic Russian exhibit at the fair, has furnished a small Russian kiosk at the head of the row of national booths erected by the different Westinghouse companies of Europe and America, and at both places, as a manifestation of Russian hospitality, Russian tea, brewed in curious old samovars, and suchari, a sweet native biscuit, are served to visitors by Russian girls wearing richly embroidered Boyarin costumes.

The pavilion in the Palace of Transportation covers a space twenty by twenty-five feet and is twenty-five feet high. It was constructed by peasant builders in the Possade Sergiewo, near Moscow, after designs by the native architect Baranowsky, who has done much important work in St. Petersburg. Although buildings of a similar character are still built to-day in the interior of Russia, on a less elaborate plan, for small homes and pavilions, the style of construction is quite primitive, the exterior being that of a forest log cabin. The logs are neatly hewn, however, and notched together so closely that no open joints remain to be plastered, as in American huts. The rafters of the high roof, also, are mortised into the plate, and no nails whatever are necessary in the construction—the entire building having been shipped to this country in boxes. The fantastic taste of the peasants is indicated in the curiously sawn eaves, gables and cornices, which are elaborately ornamented and painted in the gayest colors. The material used throughout is a white pine from the forests around Moscow, very effectively stained in the case of the carved furniture, all the interior decorations having been designed by Durnowo, whose works have been highly appreciated in the Russian buildiugs at many international expositions. The ornamental pottery and bric-a-brac were collected from various museums to show characteristic Russian art of various periods, and the hangings in the pavilion and in the kiosk follow out the general design of the interior artist, as is customary in Russian decorating, and were made of wool by peasant workers. One entire wall is covered by a hand-painted map of the world, by Ingenier Prochanof, with Russian text, the only large map on the grounds, and Russian visitors are further attracted by files of newspapers and periodicals. U. Grant Smith, brother of the general manager of the Russian Westinghouse Company, is in charge of the Russian exhibit, and Gospodin M. N. Konshin of St. Petersburg receives and welcomes his countrymen at the fair.





THE YALE & TOWNE ELECTRIC HOIST.

HEREWITH is illustrated the electric hoist recently developed by the Yale & Towne Manufacturing Company, of Stamford, Conn. The hoist is made in five sizes to meet different requirements. It is compact and may be moved about and utilized wherever current is available. The motor is placed above the oil submerged parts of the hoist and the motor shaft bearings prevent the possibility of oil entering the motor. The improved oiling devices preclude heating from overload or injury from the high temperatures usually existing near the ceiling. The load is taken on wire hoisting rope of the toughest steel, wound on grooved drums that are keyed direct to the main shaft. At the bottom hook the steel hoisting rope passes around an equalizing sheave, thereby balancing the strain. All parts under tension or subject to transverse strain are of forged steel or wrought iron. The hoist balances on its single upper hook whether loaded or empty, and pulls in a true vertical line throughout the lift. The single swivel hook suspension allows the hoist to pull as well at any angle. The working parts are enclosed in an oil tight iron casing, which excludes the dust and water, at the same time insuring thorough lubrication.

The hoist is operated from the floor, and is equipped with a telescoping controller rod, enabling the workman to control it from a point in full view of his work without depending on signals to a crane operator. An automatic cut-off prevents the load from being hoisted too high. The adaptability of such a hoist to power houses and other places where machinery or heavy material of any kind requires moving is readily appreciated.

PUMPING MACHINERY AT ST. LOUIS.

FORTY types of pumping machinery at the St. Louis Exposition are described and illustrated in a handsome pamphlet, eight and one-half by twelve inches in size, now being distributed by the International Steam Pump Company, of 114 Liberty street, New York City. Under this heading are included not only the many types of pumps exhibited, but also air compressing and steam condensing apparatus, cooling towers, vacuum machines, water meters, etc. The processes in which these machines are employed on the Exposition grounds, such as timber preserving and refrigeration, are fully explained and diagrams and graphical charts are employed to illustrate the design and arrangement of apparatus. A striking view of the Grand Cascade is shown on the cover and the immense Worthington turbine pumps by which the water is supplied are described in the text. This publication is distributed gratis.

DOBLE-RYERSON.

THE Abner Doble Company, of San Francisco, engineers, manufacturers, iron merchants and special agents, announces the completion of negotiations by which it has become the Pacific Coast representative of Joseph T. Ryerson & Son, of Chicago, New York and Pittsburg, dealers in high grades of iron and steel for railroads, boiler manufacturers and workers in sheet iron and steel, also machinery, tools and specialties. This company is now prepared to name prices and to give prompt deliveries of plate steel, sheet steel, boiler tubes, rivets, beams, channels, angles, tees, special shapes, bars, bands and hoops. Also Bailey's iron, "Ulster" iron, Continental Iron Works' "Morrison" corrugated boiler furnaces, both land and marine; Cleveland power rolls, punches, shears, etc.: R. D. Wood & Co's hydraulic riveters, flange presses, etc.; Lennox Machine Company's rotary bevel and splitting shears; McGregor-Brace Company's weldless steel boiler braces; John F. Allen pneumatic riveters; Ryerson forged steel flanges; Drake-Castle pressed steel lugs; Eclipse manholes; Ryerson crabs: Wilson hangers. Pneumatic hammers, drills, air compressors, boiler test pumps, flue welders, cutters, expenders, hand and power tools for cornice and sheet metal shops.

PROTECT AGAINST THE STORMS OF WINTER.

The early fall is the season best suited for the application of paint to steel and metal surfaces. Specifiers and users of preservative paint should have a copy of "Colors and Specifications," which is published for free distribution by the Joseph Dixon Crucible Company.

TRANSMISSION.

NORTH POWDER, OR.—Men are at work on North Powder River, Oregon, preparing for the installation of an electric power plant.

EVERETT, WASH.—C. H. Crippen and C. T. Moscher are endeavoring to secure an electric light and water franchise in Arlington, Wash.

FORT STEELE, B. C.—The Gold River Mining and Power Company intends to install an electric power plant at Bull River, Fort Steele, B. C.

CHICO, CAL.—J. A. McFeely has appropriated 12,000 inches of the water of Deer Greek, in Butte County, to be used for creating power and electrical energy.

CHEHALIS, WASH.—Harry West has secured control of the water rights of Hylak Mill, Forest, and has organized a company to install an electric light plant.

EUREKA, CAL.—President B. Von Homeyer, of the Humboldt County Light, Water and Power Company, is perfecting details for the plant to be erected at Eureka.

JACKSONVILLE, OR.—The Gold Hill Development Company has completed arrangements to install a power plant at Gold Hill, Or. About 8000 horsepower will be generated.

CHILLIWACK, B. C.—The Chilliwack Light and Power Company has secured a franchise at Chilliwack, B. C., and will proceed at once with the erection of a $100,000 power plant.

SAN FRANCISCO, CAL.—The California Gas and Electric Corporation has awarded a contract to the California Electrical Works for 12,000 four-part "Thomas" insulators for operation on 60,000 volts.

ECHO, OR.—The Echo Water, Light and Power Company intends to install an electric plant at Echo, Or. A 500-light dynamo will be put in. Two engines of twelve horsepower each will run the light and water plant.

SALT LAKE, UTAH.—Jackson McChrystal and Philip Clark, of Eureka, Utah, have petitioned the Council of that City for a franchise, and, if granted, will put in electric lights and an electric street car line at that place.

GRASS VALLEY, OR.—The Council of Grass Valley, Or., has practically completed arrangements to issue bonds for $10,000 to buy and improve the electric light and water plant at that city. The present plant will be enlarged.

SANTA FE, N. M.—H. B. Holt, an attorney of Las Vegas, N. M., states that Eastern capitalists are now seeking investment in the Mesilla Valley, with a view to establishing a large central electric power plant and establishing a colony.

SKAGWAY, ALASKA.—The White's Pass and Yukon Railroad intends to install a complete modern electric plant at the shops at Skagway, Alaska, and will be prepared to furnish lights to the people of the city. An order for the plant has been placed.

SALT LAKE, UTAH.—Jones & Jacobs, of Salt Lake, will install an independent electric generating plant to furnish light to the Dooly Block, the Commercial Club Building and the new building to be erected for the Mine and Smelter Supply Company.

BOISE, IDAHO.—Thomas H. McCann and T. E. Brown, of New York, engineers connected with the Highland Power Company, have settled on plans for the restoration of the plant at Boise, Idaho. The power house will be built on the north side af the river.

BAKER CITY, OR.—John F. O'Bryant has made application to the City Council of Haines, Or., for a franchise to supply that city with power for electric lights and other purposes for a period of twenty years. The proposition has been taken under consideration.

VANCOUVER, B. C.—The Harrison Lake Power Company intends to build a new power house to utilize the 30,000 horsepower from Rainbow Falls, about five miles from Harrison Hot Springs, B. C. E. J. Fader, of New Westminster, B. C., is interested in the project.

CITY OF MEXICO, MEX.—Oscar Braniff, of the city of Mexico, has entered into a contract with the Guanajuato Electric Power Company to supply electric power to the city of Leon, Mexico. Steel poles will shortly be erected in Leon and modern equipment will be installed.

PORTLAND, OR.—H. L. Vors, a capitalist of New York city, has secured an option on the property of the Hood River Electric Light, Water and Power Company, at Hood River, Or., with a view to purchasing. Should the deal be closed it is said the light and water plant will be improved.

EUGENE, OR.—M. P. Randolph, representing the Westinghouse Company in the Pacific northwest, has been at Eugene, Or., conferring with J. W. Wilsey, of the Willamette Valley Electric Railroad Company, preparing an estimate of the cost of a power plant with which to operate their proposed electric lines.

GRAND FORKS, B. C.—R. B. Morgan, representing a syndicate of local capitalists, has made a proposition to the City Council of Chilliwack proposing to construct an electric light and power plant, using the Vedder Creek as the supply for water power. A tramway will also be constructed from Chilliwack to New Westminster.

SALT LAKE, UTAH.—John J. Chambers, a New York capitalist, is projecting an extensive power plant to be operated by energy secured from Little Cottonwood Creek, in Utah. He expects to develop 2800 horsepower to be distributed in electrical form for the operation of mines, electric lighting plants, etc., and to this end has made filings of water appropriations.

GENESSE, IDAHO.—E. S. Aldrich, vice-president and manager of the Moscow Electric Light and Power Company, has finished the erection of the pole line from Lewiston to Moscow and is now at this place finishing the local distributing pole line. It is expected that the system will be in operation by October 1st, when considerable electric power for manufacturing purposes will be installed.

EUREKA, CAL.—It is rumored that the late sale by the Humboldt Milling Company of its electric light plant to Eureka parties is the first step towards an electric road from Eureka to Rohnerville, and in time to the other towns south of Rohnerville. The company will furnish lights and power for all purposes. L. M. Hancock, the electrical engineer, of San Francisco, is reported to be interested.

TRANSPORTATION.

SALT LAKE, UTAH.—Guy Sterling, of Salt Lake, Utah, is making preliminary surveys for the new suburban electric road.

SALT LARE, UTAH.—The B. Mahler Company has been granted a franchise to construct and operate an electric railroad through Williard, Utah.

EVERETT, WASH.—It is rumored that C. H. Crippen and C. T. Mosher contemplate building an electric railway between Arlington and Snohomish.

CITY OF MEXICO, MEX.—The surveys of the new route of the proposed electric railway from Guadalajara to Chapala, Mex., have been completed.

SPOKANE, WASH.—Active work on the electric railway between Tacoma and Olympia will be commenced as soon as the surveying operations are completed.

CHIHUAHUA, MEX.—Benjamin Barrios has obtained a concession from the Mexican Government to build an electric railway from the City of Mexico to Puebla, Mex.

EVERETT, WASH.—E. G. Kruger, of Silver City, has asked for a franchise from the County Commissioners of Snohomish County, Wesh., for an electric line over the county road between Galena and Mineral City.

SPOKANE, WASH.—The Washington Water Power Company intends to ask the Council of Spokane, Wash., for a franchise to extend the Astor Street car line to the Lidgerwood loop. Over a mile of track will have to be built.

PORTLAND, OR.—Dr. J. M. Boyd, of Spokane, Wash., is promoting a scheme to build an interurban electric road from Baker City to La Grande, Or. The new company will ask for a franchise through the city streets. The proposed line will be operated with power from Rock Creek.

WATSONVILLE, CAL.—The stockholders of the Watsonville Transportation Company have decided to issue $200,000 in bonds for improvements. All preliminary arrangements have been made for the extension of the electric line to Vega. Work will be started immediately and pushed rapidly to completion.

PORTLAND, OR.—J. B. Weddell and W. E. Haycos, of Olympia, Wash., have asked the Council of Montesano, Wash., for a franchise for an electric road through that city. They propose to build an electric line from Olympia to Aberdeen, with a branch line from Gate City running through Centralia to Chehalis.

PORTLAND, OR.—The Portland and Suburban Street Railway Company, which is a consolidation of the Portland Railway Company and the City and Suburban Company, will improve the equipment of the road. Many new cars will be built and the light rails will be replaced with fifly-pound steel set in cement.

TACOMA, WASH.—The Willamette Valley Electric Railway Company, recently organized at Eugene, Or., contemplates building an electric line from Eugene to Coos Bay, Or. The company will ask the people along the route to snbscribe $300,000 in stock. The road as projected will cost about $5,000,000. J. F. Wilson, of Eugene, Or., is at the head of the company.

VACAVILLE, CAL.—The Trustees of Vacaville, Cal., have awarded a franchise to J. W. Hartzel, of Vallejo, and his associates, for an electric road through Vacaville. Part of the system is now running to tide water at Vallejo, and the new franchise is a link in the general plan of development in northern California. The line will follow the public roads to Vallejo. The franchise is now complete for the entire route.

STOCKTON, CAL.—It is reported that the system of the Stockton Electric Railroad Company is to be reconstructed as soon as the San Jose and Los Gatos interurban line is completed. The road is twelve miles long, and it is estimated that about three months will be required to complete it. The Stockton system will be reconstructed from a narrow to a standard gauge system and will be extended to Lodi and probably further.

SALEM, OR.—Hon. Mayor Frank W. Waters has made a proposition to the people of Liberty and Rosedale, Or., regarding the proposed electric line extension to those neighborhoods. He proposes to furnish and install the necessary rails, wires and tracks and furnish the required power, energy and cars, if the residents will furnish free of cost the right of way, do the required grading and furnish the ties and trolley wire poles.

COMMUNICATION.

VICTORIA, B. C.—Work will soon begin on the land telephone lines to form part of the connection between the mainland and Vancouver Island.

LOS ANGELES, CAL.—The Supervisors of Orange County, Cal., have granted a franchise to George A. Edgar to operate a telephone line in the county.

SALEM, OR.—W. D. De Varney, president and manager of the Independent Telephone Company, has arrived at Salem, Or., and will make formal application for a franchise in that city.

PORTLANE, OR.—A. B. Cousins, of Portland, Or., manager of the Galfee Consolidated Mines Company, is arranging for the construction of a telephone line from Merlin to Galice, Or.

FORTUNA, CAL.—The Upper Mattole Telephone Company has been organized at Fortuna with E. J. Etter as president and F. Roscoe as secretary. The place of business is Upper Mattole.

CITY OF MEXICO, MEX.—Jose Sitzonstatter, of the City of Mexico, has secured a concession from the Mexican Government for the installation of a new telephone system in the City of Mexico.

IMPERIAL, CAL.—C. W. Hinchcliffe, of Tucson, Ariz., manager of the Arizona Telephone Company, is in consultation with W. F. Holt, owner of the Imperial, Cal., line, with a view to an extension of the system.

QUINCY, CAL.—John Stark states that a contract for the construction of a telephone line in Indian Valley will soon be let. It is expected that the line will later be connected with Greenville and Crescent Mills.

LEWISTON, IDAHO.—The Pacific States Telephone and Telegraph Company, at Lewiston, Idaho, announces that the construction of a line to Mohler will be commenced at once and will be completed within a short time.

BOISE, IDAHO.—D. S. Murray, manager of the Rocky Mountain Bell Telephone Company, has decided to recommend to his company that a line be constructed reaching both the Roosevelt and Big Creek sections of the Thunder Mountain district.

LOS ANGELES, CAL.—A telephone franchise for most of the desert country of San Bernardino County has been sold by the Supervisors of that county to N. W. Terr for $55. It is believed the line is to be a part of the new Arizona and California Telephone Company.

CLEVELAND, WASH.—A. Hironimous is building a telephone line from Arlington, Or., by way of Cleveland and Jersey, to Brickleton, Wash., upon the completion of which he will construct a line to Mabton, Wash., by way of Blue Light and Glade. Part of the material for the former line is on hand.

SALEM, OR.—The farmers living along the Greer-Griffith road, near Salem, Or., will hold a meeting at Oak Ridge school house soon to formulate plans for the erection of a rural telephone line along the road. It is proposed to connect the line with the Pacific States Telephone and Telegraph Company's office at Salem.

SAN FRANCISCO, CAL.—A new building is to be erected by the Pacific States Telephone and Telegraph Company on Bush Street and Belden Place, San Francisco. It will cost $100,000. It is the intention to purchase new machinery and install a switchboard. The company is also preparing to reconstruct its entire system in San Francisco.

INCORPORATIONS.

ALBUQUERQUE, N. M.—The Albuquerque Electric Power Company, Albuquerque, N. M.; capital stock, $50,000; incorporators, William L. Iliff, William B. Childers, Edward Allen, and others. The object is to generate electricity.

OREGON CITY, OR.—The Western Oregon Telephone Company, Willamette, Or.; capital stock, $2,000; incorporators, Charles Baker, G. P. Gross, S. S. Kruse, and others. The company proposes to conduct a general telephone business.

ROSALIA, WASH.—The Interstate Telephone and Telegraph Company, Pine City, Wash.; capital stock, $5000; incorporators, J. J. Slephens, of Thornton; N. Howard, of Thornton, and others. The company will build lines from Pine City to Thornton, Wash., thence to St. John.

MISCELLANEOUS.

SAN FRANCISCO, CAL.—The Pacific Press Publishing Company has equipped its new building, at Mountain View, Cal., with Nernst lamps.

PARRAL, MEX,—The work of installing the electric pumping plant at the Pamillo Mine of Pedro Alvarado will be commenced in the near future.

SAN FRANCISCO, CAL.—Mr. J. C. Martin, Jr., formerly vice-president of the Holland Company, has organized the J. C. Martin Company and opened an office and salesroom on New Montgomery Street to carry in stock and sell, railway, marine and power plant specialties, featuring the Martin crude oil burner for ocomotives.